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VOL. 9-10, 1970-72

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VOL. 9. No. 2 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY OCTOBER 1970

CFTRI

'Nations Must Share Benefits of Atomic Energy'

Text of speech delivered by Dr. Vikram A. Sarabhai on his election as President of the Fourteenth General Conference of the International Atomic Energy Agency in Vienna on 22nd September 1970.



Dr. Vikram Sarabhai, Chairman, AEC, speaking at the 14th General Conference of IAEA.

I WISH to thank the General Conference for the great honour done to my country and to me by electing me to this high office.

Under the leadership of Jawaharlal Nehru, Dr. Homi Bhabha not only established the relevance of atomic energy to a developing nation but also demonstrated the role that scientists and engineers of such nations can play internationally in promoting the peaceful uses of atomic energy for the benefit of all. Homi Bhabha significantly contributed to the creation of this Agency and to the convening of the first United Nations Atoms for Peace Conference in Geneva of which he was President. That Conference was a landmark in the unique transformation of a technology developed for military uses to one destined to play a most important role in peace time.

I am deeply conscious of the great trust and responsibility that the delegations at this Conference have reposed in me. I particularly appreciate the kind references made today.

Common Obligation

In atomic energy, we stand at crossroads. This lends very special significance to the deliberations of this Conference and the continuing work currently undertaken by many other bodies connected with this Agency. It is our common obligation to ensure that we establish a base for the future, recognising the inherent character of scientific and technological innovation which represents man's most profound urge for knowledge and self-advancement and must therefore be available to all in equal measure. It is our responsibility to take note of the compelling urgency for economic and social progress of all people and to take concrete measures in spite of ideological and political differences between nations, traditional hostilities and competition and the insecurity generated by these forces. This calls for wisdom and maturity of a high order, of trust as well as understanding, and above all of self-restraint. The importance of taking equitable decisions and adopting procedures strictly in conformity with the letter and spirit of the statutes of this Agency must constantly be kept before us.

A most positive development during the past year has been the work of the safeguards committee to prepare for new responsibilities which fall on this Agency from the non-proliferation treaty. There are already positive signs of an emerging rational approach concerning the manner in which safeguards should be applied. The request to the Director General to examine the financial implications of the safeguards responsibility of the Agency in the future is extremely important since at the present time no one appears to have a clear idea of the magnitude of these responsibilities and the manner in which the Agency can maintain an appropriate balance between its positive promotional activities and the control functions to prevent misuse.

There is understandably today a deep concern about pollution of our environment. Delegations to this Conference are aware of the lengths to which efforts have been made in the

(Continued on page 3)

Careers in Physics

Report on a panel discussion in Bombay, by S. K. Mitra of the Tata Institute of Fundamental Research, Bombay

A panel discussion on "Careers in Physics" was organized by the Indian Physics Association in Bombay on August 22 at the St. Xavier's College, with physicists from industry, research laboratories and educational institutions, and students from local colleges among the participants. The panel consisted of Fr. Prof. J. V. Bonet (St. Xavier's College, Bombay), Dr. P. K. Kelkar (Director, Indian Institute of Technology, Bombay), Dr. R. Ramanna (Director, Physics Group, Bhabha Atomic Research Centre, Trombay), Dr. B. D. Toshniwal (Managing Director, Toshniwal Brothers), Prof. B. M. Udgaonkar (Tata Institute of Fundamental Research, Bombay), and four students from local colleges. Fr. Bonet presided and also acted as a moderator.

Traditional Role

The discussion was initiated with questions on post-graduate education in Bombay, which, it was stated, was biased towards pure physics. The need for a counselling body to make aptitude studies and advise students on proper choice of courses and job opportunities for various specializations was emphasized. In this context, it was indicated that the best way was for the teacher to play the traditional role of "philosopher, friend and guide."

A student's question: "Where does our country, with its present social and economic problems, stand in the field of pure research? Can we afford to do fundamental research at the present stage?" elicited Prof. Udgaonkar's reply: "There has been a lot of misunderstanding on the issue of support to pure research in the country. One might think of doing only applied research, borrowing products of fundamental research from other countries. But this would lead to a derivative scientific culture and not a culture of one's own which is so important for growing independence in thinking and self confidence. For the latter purpose, there is nothing like pure science, whose standards of excellance are international". The question of providing certain minimal research facilities became a subject of discussion in this context. Dr. R. Ramanna stressed the importance of proper formulation of programmes and the necessity of generating the required facilities in the country itself. Dr. Kelkar commented that modern research was a rather complex exercise and a certain critical size of concentrated effort is essential to achieve something meaningful.

"What about the brain drain? Does it indicate exuberance of talent in this country or is it because we are not in a position to provide right facilities that young physicists are leaving the country? What has been done to reverse it?" asked a student. Regarding this vital question a note of optimism was struck by Dr. Kelkar who said that he had seen a reverse brain drain taking place. He remarked, "The main hurdle in this process is lack of sufficient motivation for the returning scientists through appreciation of talents, more opportunities and rewards."

Practical Work

There were a number of questions regarding careers for physicists in industry. "What does industry expect from the physicist who has shown creativity and ability for critical thinking in the course of his educational career?" asked a student. "At what stage should a student of physics think of going to industry—after B.Sc., M.Sc. or Ph.D?" The questions were taken up by Dr. Toshniwal. He said that since teaching was at present book oriented, degree holders in India were hardly able to work with their own hands. Under such circumstances "industry does not want mere degree holders, but people who can deliver the goods". While agreeing that there should be emphasis on practical work in the educational system, Dr. Kelkar was of the opinion that industry should also exert to inform the physicists of what its needs and challenges are. Both Dr. Kelkar and Dr. Ramanna stressed that industry should appreciate the fact that a physicist by way of his training has certain special aptitudes, a way of thinking and an outlook which could be of immense use towards development and improvement of new products.

There were a number of questions regarding the effectiveness of the National Science Talent Search Scheme in attracting good students towards physics as a career. Some defects in the present-day undergraduate teaching programmes regarding evaluation of students were also pointed out. It was emphasized that the educational programme should ordinarily be geared to the needs of the average student and that it would be advisable to have "problem solving" as an essential part in the teaching programme. ●

BARC Reporting

Fuel Reprocessing Division

Uranium 233 is being separated from irradiated thorium elements at a facility commissioned last month. The thorium elements were irradiated in the CIRUS reactor. The aluminium clad thorium oxide element was dissolved in a full scale recirculation dissolver and the separation was carried out in a battery of air pulsed glass mixer settlers using 5% TBP as solvent. The uranium 233 product was purified by ion exchange process. Preliminary mass spectrographic analysis indicates that the material is better than 99% pure isotopically.

'Nuclear Centres Can Provide Forces of Cohesion'

(Continued from page 1)

past to safeguard against harmful pollution by the uses of atomic energy. Indeed the record so far has been excellent. However, it is timely that the Agency bring together specialists to review this problem in the very best traditions of scientific objectivity and propose measures to ensure that in the development of nuclear energy utmost caution will be exercised. I have no doubt that these activities will help to create informed public opinion essential for future growth.

Forces of Cohesion

A long term plan backed by appropriate commitment of funds, personnel and facilities for taking the benefits of atomic energy to the large number of developing nations is essential if the problems which are likely to be faced in the world in the next decade are to be effectively tackled. We should note that unless we adopt very special measures involving new norms of international collaboration and assistance, the gap between the atomically advanced nations and those not yet in this category, will rapidly widen as in other areas of development. Moreover, if the full benefits of atomic energy are not quickly harnessed for development, we shall be creating economic and social conditions far more dangerous to the security of the world than the clandestine diversion of fissile materials for military use, the prevention of which we are all anxious to ensure. It is my conviction that just as major hydroelectric and irrigation schemes related to common natural resources tie together the economic viability of nations and put a premium on coexistence overriding political differences, so can low cost nuclear energy centres provide the forces of social and political cohesion in all inhabited regions of this troubled world.

A study is currently being made by the United Nations of the benefits of space research and their applications to developing countries. A similar comprehensive overview for atomic energy is probably a prerequisite to future initiatives of this Agency.

I wish to express appreciation on behalf of all of us to the Director General and his staff for the untiring and dedicated services to the Agency.

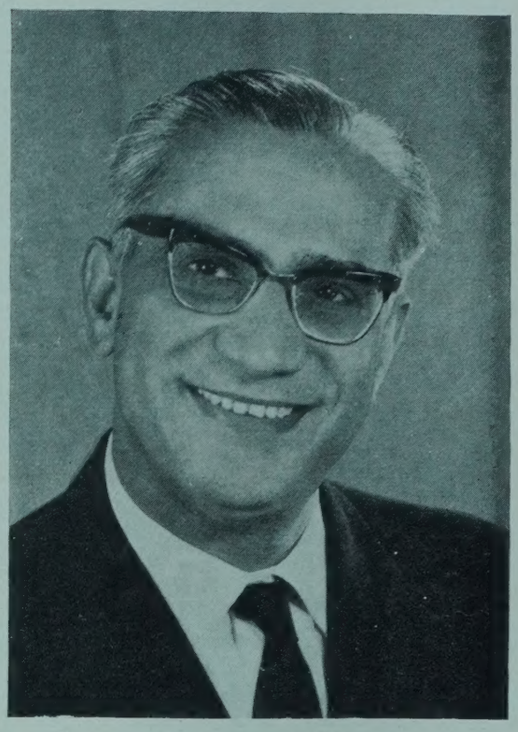
Ambassador Trivedi Urges More IAEA Emphasis on Promotional Activities

SPEAKING at the 14th General Conference of the International Atomic Energy Agency in Vienna on September 25, India's Ambassador to Austria and Leader of the Indian Delegation to the Conference, Shri V. C. Trivedi, said that the current session of the Conference marked a significant stage in the evolution of ideals and aspirations which inspired the creation of the organisation. He said there were two issues of vital importance before the Conference which had an intimate bearing on the philosophy of the organisation and healthy development of its institutions and activities.

Promotional Activities

One of these, Ambassador Trivedi said, is the proposal to enlarge the composition of the Agency's executive organ, the Board of Governors. India supported this proposal and believed that this should be done in such a way that the abiding validity of the Philosophy of the Agency and the fundamental soundness of its structure were maintained and strengthened.

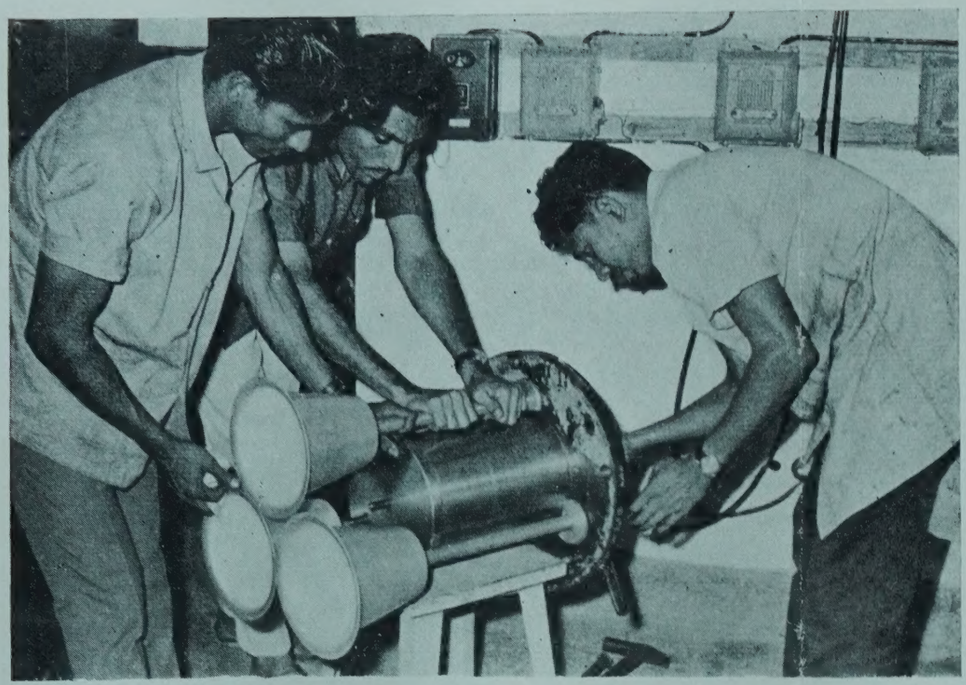
The second issue related to the question of finances. The Agency was established to accelerate the contribution of atomic energy to peace and prosperity throughout the world, bearing in mind the special needs of the developing countries. Unfortunately, recent trends showed a distortion of the healthy balance between the promotional and the regulatory activities of the Agency as the safeguards activities were accounting for a vast proportion of the Agency's resources. Ambassador Trivedi said that the policeman's functions should not be allowed to overwhelm or override the more positive promotional activities of



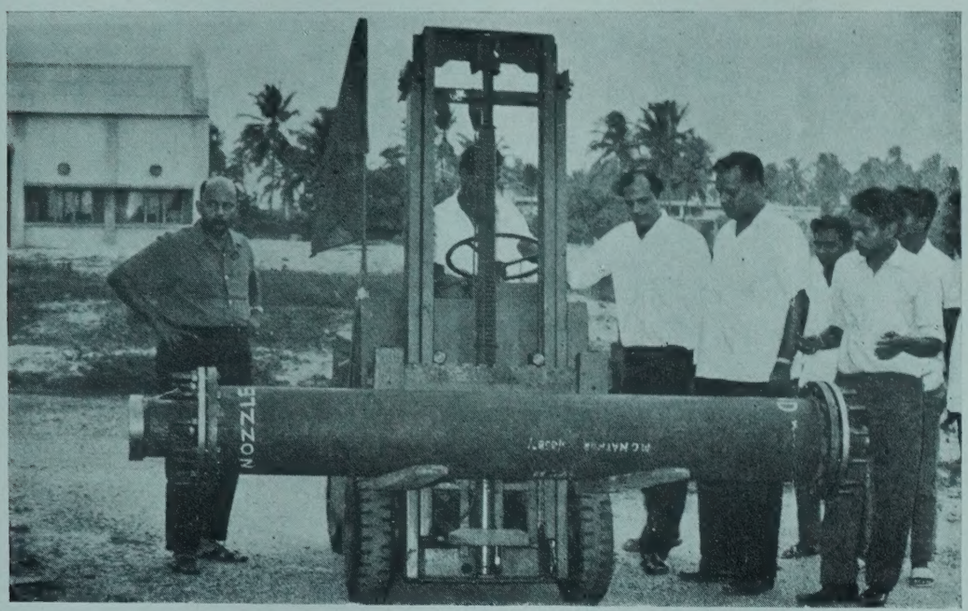
Shri Vishnu Trivedi

assistance to Member States in the peaceful uses of atomic energy.

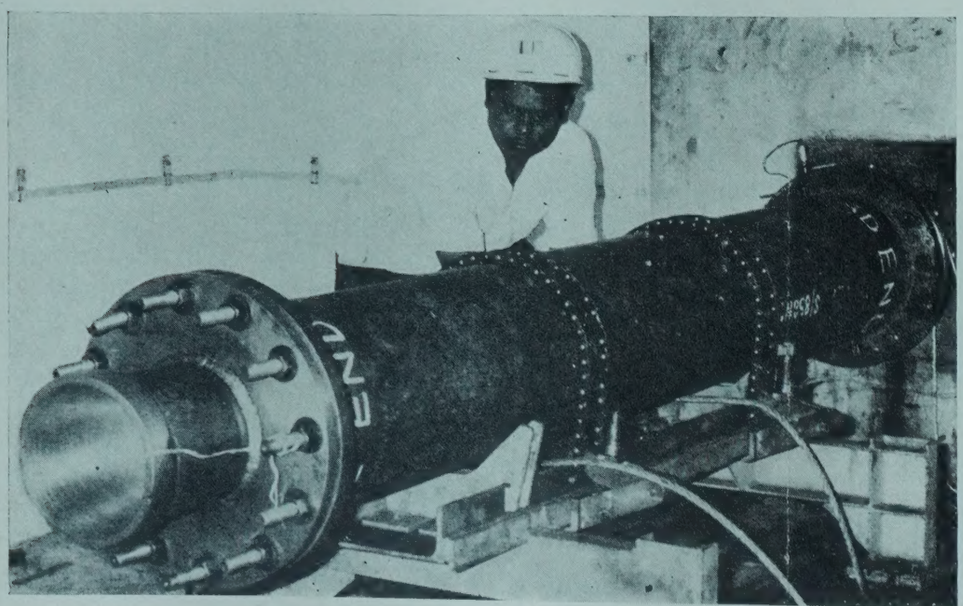
Refering to India's progress, Ambassador Trivedi said that the Indian atomic energy effort was now twenty-five years old. It was a fitting celebration of its silver jubilee he said when the Prime Minister dedicated to the Nation in January this year the Tarapur Atomic Power Project which was the first such station in the developing world and the largest in Asia. He added that simultaneously with its own progress in peaceful uses of atomic energy, India had been making special efforts to promote regional cooperation in order to share with its neighbours its own experience in that field. India, he said, was also providing several fellowships to young scientists from developing countries and contributing handsomely to the Agency's fund of voluntary contributions for technical assistance. ●



Above : Preparation of feeding assembly for propellant casting unit.
Below : RH-300 static motor relay being moved to static test bay.



Below : RH-300 motor being prepared for static test.





PROVIDING POWER FOR ROCKET VEHICLES

Work at the Propellant Engine the Space Science and Technol

Maiden flight (Feb. 21, 1969) of the first TH

IN February 1969, an indigenous rocket soared into the Thumba sky powered by a propellant developed at the nearby Space Science and Technology Centre at Veli Hill. The successful performance of the rocket marked an important point in the development programme of the Propellant Engineering Division of the Centre which has been working in this area for some years. During these 20 months after the first propellant was tested, work relating to rocket fuel and associated materials has come a long way and is keeping step with the activities of other groups in the Centre — directed toward the planned satellite launch attempt of mid-1974.

Complex Job

Propellants could be either liquid or solid, which again could depend on the type of rocket motors and their performance requirements. The development of propellants is a complex job entailing analysis and testing of hundreds of chemicals, and composing them in different computations and permutations till a formulation with the desired chemical, thermal and physical properties is evolved. As a major part of the work in India in this



of
eli Hill.

cket with indigenous propellant.

area is on solid propellants we may give an idea of its rudiments. A simple solid propellant consists of an oxidiser and a binder as major ingredients with doses of chemicals for imparting special properties to it. The binder keeps the particles of the "grain" together, bound in the configuration in which it is cast. Besides this, are an insulation material which forms a layer between the propellant and the rocket shell and an inhibitor which prevents undesired burning.

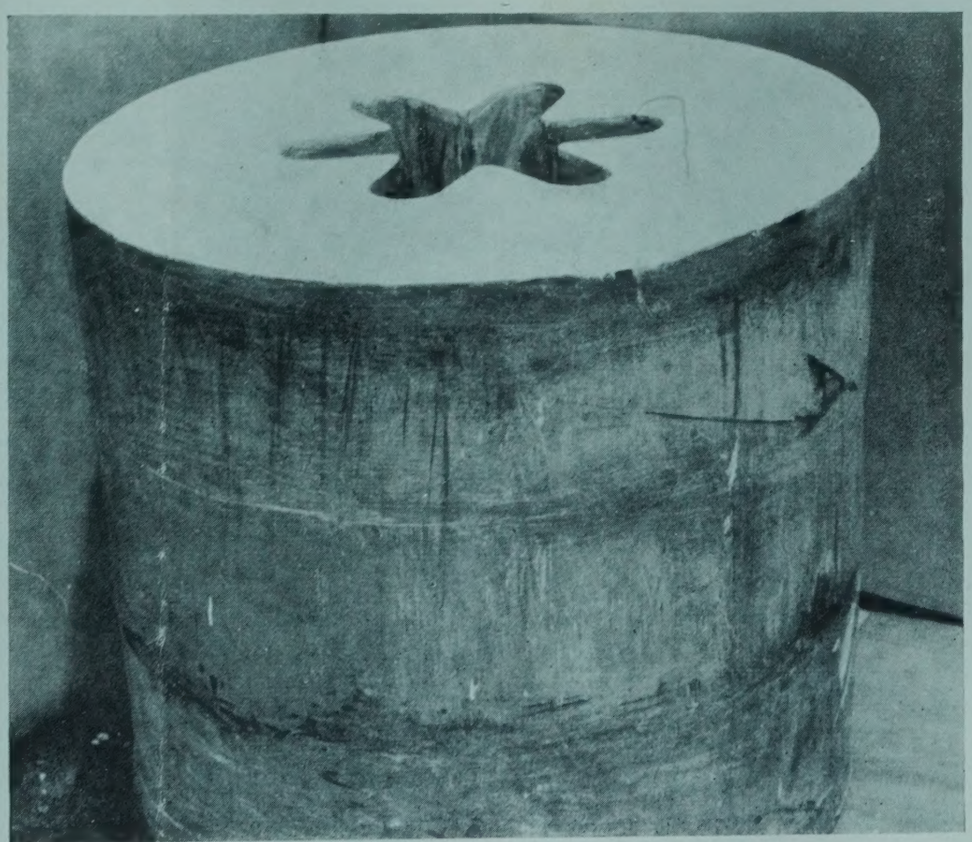
The development of propellants has to be preceded by extensive research in many areas. The exact requirements of the launch — altitude, trajectory, atmospheric conditions and the assigned objective must be clearly defined before work on the actual propellant commences. Thus it would be seen that there is a great difference in the propellants of a sounding rocket with a maximum altitude of 200 km., and a satellite launch vehicle which could be anywhere upto 40,000 km.

Development of Substitutes

At SSTC, the Propellant Engineering Division carries on research and development in the area of propellants, igniters, binders, inhibitors, and work



Above : End inhibition for a small test rocket. Below : A part of a 1000 mm diameter sample grain cast using stage casting and segment bonding technique. Propellant grains cast in four successive stages by this technique and subsequently cured have been tested.



Propellant Development Activity Part of Satellite

(Continued from page 5)

connected with chemical analysis, machining, testing (which includes thermo-chemical studies) and developing substitutes for fine chemicals which are not available in the country. The Division is also engaged on the development of cryogenic engines.

The Division has so far developed over ten propellants with specific impulses from low to high ranges, with a range of burning rates, compatible inhibitors and igniters. It has instituted a special study for developing composite, composite-modified and cast doublebase propellants with high energy content and improved mechanical properties. High energy and high density propellants are of great practical importance to any programme for satellite launching as they can favourably influence the design of motors, or improve the performance of any particular design.

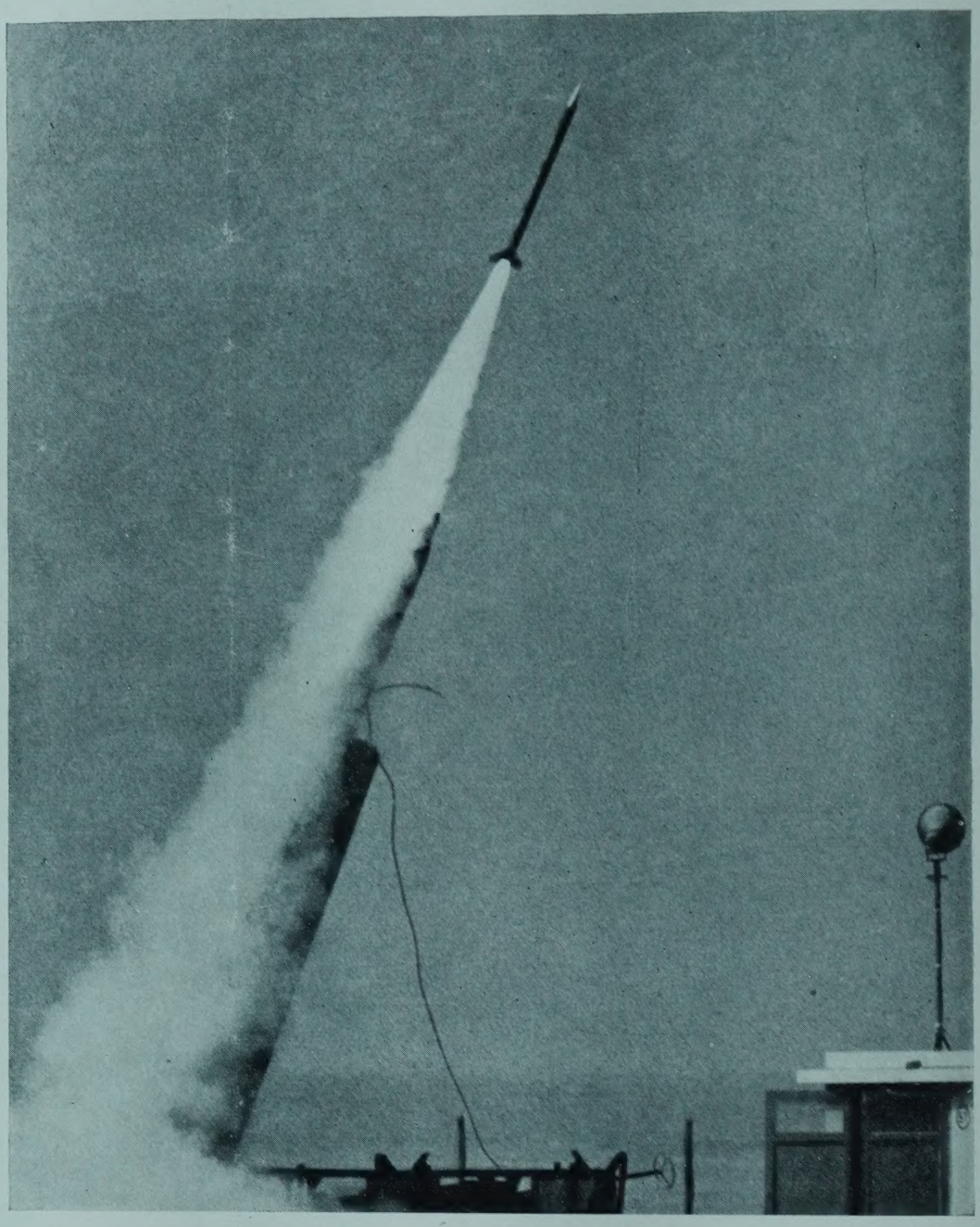
As stated earlier, the development of propellants involves simultaneous work on binders, igniters, inhibitors, insulation material etc. And, besides developing suitable materials, a whole exercise has to be gone through to cater for different propellant configurations etc. to ensure maximum thrust and uniform burning.

Other Ingredients

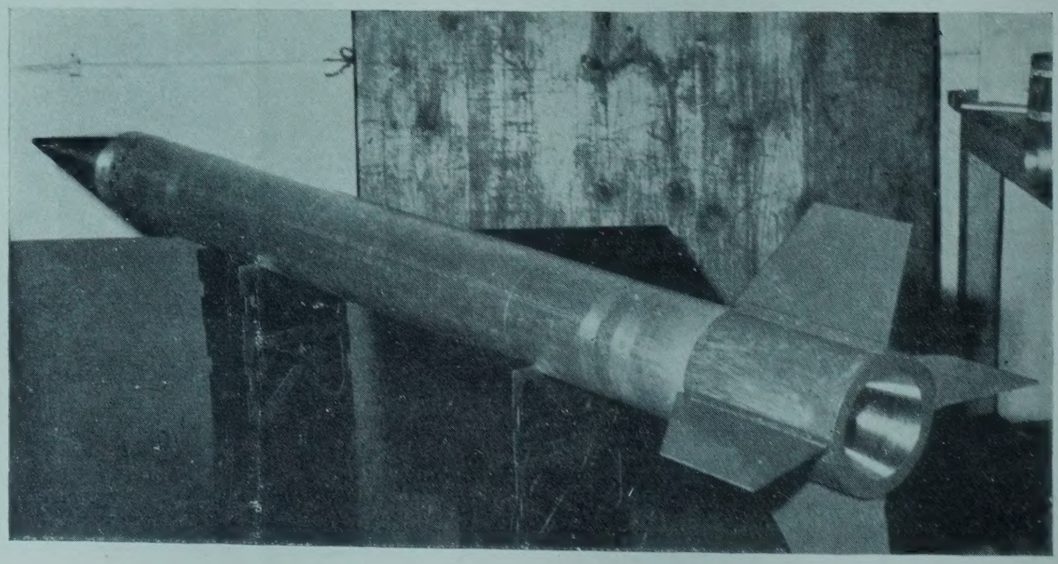
The Division has developed compositions capable of giving specific impulses over a high range required for satellite launch applications. The propellants will be essentially of composite modified type.

Among the other major ingredients of a propellant are of course the binders. The ones currently under development belong to the category of polysulfide, hydroxy terminated polyesters for polyurethane, epoxy, boron-polyesters, phenol formaldehyde, urea formaldehyde, natural rubber and PVC.

Indigenous polyesters have already been employed in propellants which have been satisfactorily tested for reliability, reproducibility and storage in motors of upto 300 mm diameter. Phenol formaldehyde is in use for



RH-100, with indigenous propellant. Below : India's first fibre glass rocket. It was powered by high energy propellant developed by the Propellant Engineering Division.



making phenolic linings—a technique which has been successfully employed in all fibre glass rockets launched so far. Plasticisers play a vital role next to resins in the preparation of propellants. Although a few plasticisers are available commercially, there is always a need for new plasticisers since commercial ones may not be suitable for special types of resins that are used in the propellants. New plasticisers have been developed in the Division.

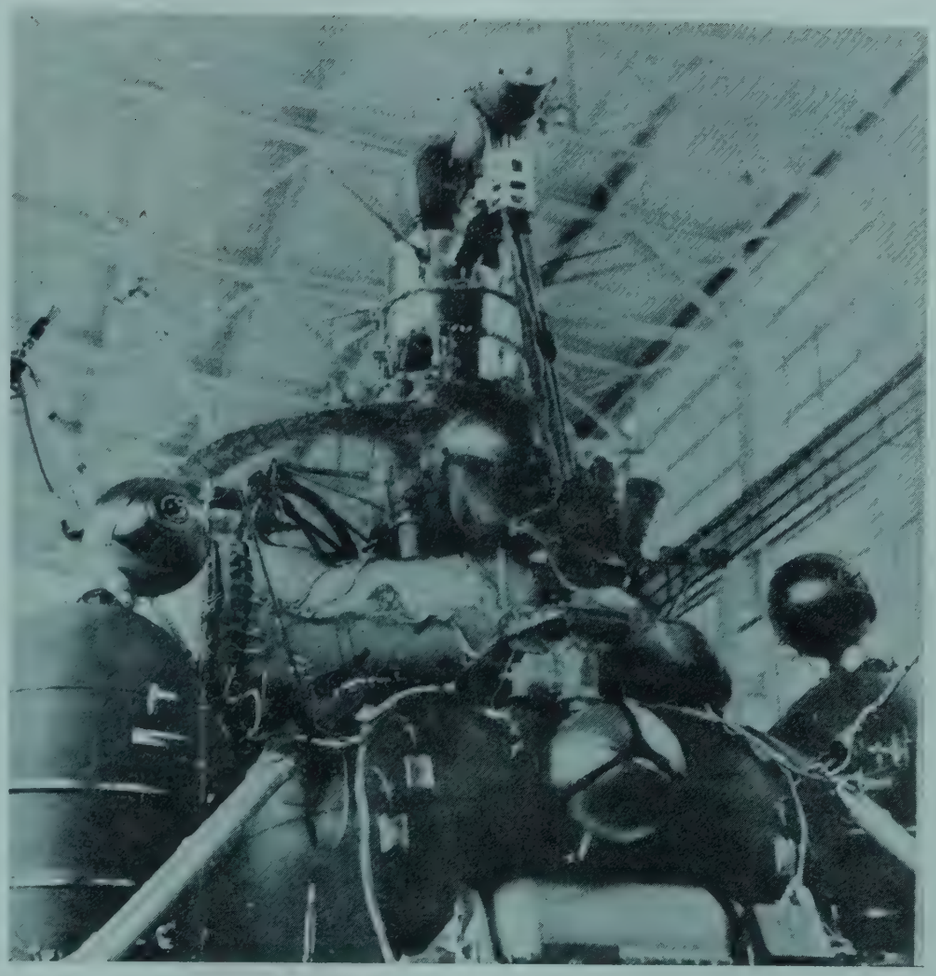
Besides binders, the other item receiving attention is the igniter. Various igniter mixture compositions to suit specific needs of different propellant systems are presently being tried out. Among the projects under development are triggering mechanisms, development of ignition systems, processing of igniter powders, combustible holders, scaling up of ignition systems for big size boosters, and assembly of igniters. Ignition systems have been supplied by the division for at least 2000 motors of different sizes. About 400 motors of different sizes have been tested exclusively for the evaluation of different igniter systems.

Fast Burning Propellants

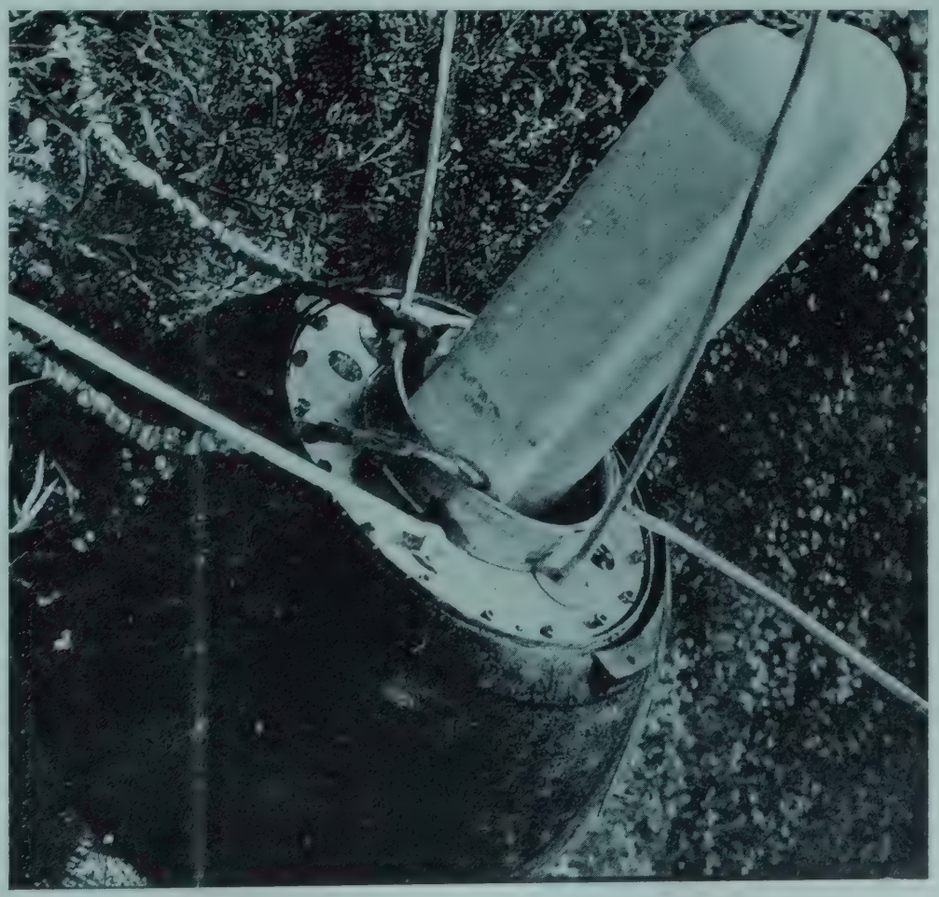
Another important area of development on which the Division is engaged is that of testing motors of different sizes and burning duration, for studying the burning characteristics of indigenous propellants at low and high pressures over a period of burning time and testing the inhibiting, insulating and nozzle materials over a length of time under the severe conditions prevailing in and around the combustion chamber. Also under development are fast burning propellants with embedded metallic wires for booster applications. End-burning motors upto 300 mm dia. and burning for durations of upto 35 seconds have already been tested, while preliminary work on bigger size motors burning for longer durations is underway.

One of the interesting responsibilities of the Division is of developing substitutes for some fine chemicals

(Continued on page 8)



OUTSTANDING EXPERIMENT. This is Luna-16, the Soviet automatic station which brought back lunar soil samples on September 24th. Below is the container shown during a trial descent.



Propellants for SLV

(Continued from page 7)

which are expensive and also not available in India. Some of these chemicals are essential for propellant processing. The Division is researching for evolving substitutes as well as for synthesizing chemicals which are not readily available in required quantity and purity. It has already developed processes for a number of chemicals used in propellant production.

An interesting piece of research work going on at SSTC is relevant to the satellite launch programme. It has facilities for casting solid propellants for small rockets but the satellite launch vehicle proposed will have a diameter at base of 1000 mm and will stand 21 metres high. The casting of a large size booster for a satellite application cannot all be done in one single operation for want of such large capacity mixers, casters etc. The usual procedure under such circumstances is to build-up the final charge from smaller blocks which can be cast in a single operation using segmented bonding technique.

The possibility of using small size equipment for producing segments of propellant grains for ultimately assembling the final satellite size grains by "segment bonding" has been under study for a long time. As a result, a method of casting in stages after suitable adjustment to the propellants pots life has been successfully tried in small sizes. Propellant grains cast in four successive stages by this method and subsequently cured have been tested.

Propellant for SLV

As a first step in the evaluation of "stage casting" combined with segment bonding as a method of producing the very large satellite boosters with relatively small size mixers etc., an exercise was carried out to cast a one-tonne charge of diameter 1000 mm and length 1000 mm with a 50 kg. mixer. The oxidizer was substituted quantitatively with an inert material. The grain produced in this way was found to be quite satisfactory in respect of the strength of bond between segments and the structural integrity. The grain could withstand a good deal of physical handling.

Along with its focus on development of solid fuels for satellite launch vehicles, the Division has also embarked in a parallel direction—develo ment of liquid fuel with a possib application in space boosters in mi It has a project for development cryogenic techniques for use in liqu engines.

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NUCLEAR PHYSICS AND SOLID STATE PHYSICS SYMPOSIUM—1970

Venue : Madurai University, Madurai

Dates : December 27 to 30, 1970

Deadlines : Abstracts: November 1,1970

Papers : December 10,1970

1. NUCLEAR PHYSICS:

a) Nuclear Reactions
b) Nuclear Spectroscopy
c) Nuclear Theory
d) New Experimental Methods and Techniques

2. SOLID STATE PHYSICS:

a) Magnetic Properties of Solids
b) Electronic Properties of Solids
c) Thermal and Dynamical Properties of Solids and Liquids
d) Low Temperature Behaviour of Solids and Liquids

Nuclear Physics Abstracts and Papers should be sent to:

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Nuclear Physics Division
2 119s, Modular Laboratories
Bhabha Atomic Research Centre
Trombay, Bombay 85

Solid State Physics Abstracts and Papers should be sent to:

Dr. B. A. Dasannacharya
Nuclear Physics Division
2 113H, Modular Laboratories
Bhabha Atomic Research Centre
Trombay, Bombay 85.

Local arrangements are in the charge of:

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Department of Physics
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Edited and published by Jagannath Sharma, Publications Officer, Dept of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 1, and printed by him at Conway Pvt. Ltd. (Printers), 6, Tulloch Road, Bombay 1.

Registered No. R.N. 9002/62

NUCLEAR INDIA

VOL. 9. NO. 3 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY NOVEMBER 1970

Measuring Potassium Content in Infants

A whole-body counter for measuring total body potassium in infants has been set up by the Health Physics Division of the Bhabha Atomic Research Centre. The counting system consists of two large volume (18 litres each) plastic scintillation detectors. Each detector, in the form of a cylinder with an elliptical cross-section (major axis : 50.8 cm and minor axis 25.4 cm) and height 17.8 cm, is viewed by two photomultipliers. The detectors are arranged 38 cm apart on the two sides of a plexiglass bed which is mounted on ball bearings. The bed is pulled out for positioning the child before counting. The entire system is located inside a steel room having 20 cm thick mild steel all around. The total body potassium is measured by counting the naturally occurring radioactive potassium (^{40}K) present in the body of the infant. By "sandwiching" the infant between the plastic scintillators, a high counting efficiency of 0.28 counts per second per gramme of potassium is achieved.



Plastic scintillator system with infant in counting position.

Pilot Study

The total body potassium content will give the pediatrician an idea of the lean body mass of the infant. Apart from the importance of knowing the changes in total body potassium during growth of an infant, the clinical usefulness of the whole-body counter for the determination of total body potassium in different disease states is eminent. Changes in the body potassium, (both capacity and content) in malnutrition are well known.

The Department of Pediatrics, K.E.M. Hospital, Bombay has undertaken a pilot study to find out the changes in the body potassium before and during treatment of both protein and calorie malnutrition. This will help in scientific treatment of malnutrition. Scientists from the Health Physics Division of BARC are collaborating with them in this study. More than 60 measurements have been made so far with this counter.

Other Applications

The Health Physics Division has also developed simple and low-cost whole-body radioactivity monitors using shadow shield scanning bed and shielded chair geometries. Although these systems have been designed primarily for occupational radiation protection measurements, they can also find ready application in the rapidly growing field of nuclear medicine. A scanning bed shadow shield counter has recently been installed in the Grant Medical College, Bombay, to evaluate its utility in clinical radioisotope turnover studies. The counter is being used for the study of absorption of vitamin B_{12} in normal and diseased persons, using ^{58}Co labelled vitamin B_{12}.

World Nuclear, Space Round-up

Japan's Nuclear Power Programme

A JAPANESE Government report estimates that nuclear generating capacity in Japan will have reached 8,600 MW by 1975 and 60,000 MW by 1995. This would account for some 40 per cent of Japan's entire power output, which goes well beyond earlier assessments.

The report states that it is reckoned by industrial circles that 18,000 tons of natural uranium will be needed by 1975, and 120,000 tons by 1985. Japan depends entirely on overseas resources to meet its nuclear fuel requirements.

At present the United States is the sole supplier of the enriched uranium used in Japan's nuclear power plants. The Americans have agreed to continue supplying fuel until 1991 for 26 plants the construction of which is to begin by 1973.

Two nuclear power plants are now being operated in Japan on a commercial basis. They will be joined by two more by the end of this year.

Satellite Network for the United States

THE three major American television and radio networks, viz., the American Broadcasting Company, Colombia Broadcasting System Inc., and the National Broadcasting Company have recommended that a domestic satellite network or a specialised microwave system could replace traditional television and radio programme distribution facilities in the United States at an annual cost saving of 25 to 35 per cent. From a study they conclude that the change from the traditional American Telephone and Telegraph facilities could be made without compromising the flexibility, reliability or signal quality of the present facilities.

The satellite system would require about 160 earth stations and as many as 25 launch attempts over a 20 year period, taking into consideration the probability of launch failures and the anticipated loss of satellite power.

The microwave system would encompass more than 18,000 "system miles" consisting of approximately 600 towers.

The estimated annual cost of the new systems would range from $ 50 million to $ 55 million against $ 70 million the networks are now paying for American Telephone and Telegraph facilities.

Salt Mines for Radioactive Waste

THE United States Atomic Energy Commission has announced the tentative selection of an abandoned salt mine near Lyons, Kansas State as the nation's first underground radioactive waste repository. It will be a demonstration vault for the long-term storage of solid high-level and long-lived low-level radioactive wastes. The area chosen will be known as the Kansas Nuclear Park—a $ 25 million project. For several years, these salt belts have been the object of intensive studies by scientists involved with various governmental agencies concerned with storage of radioactive wastes. The State of Kansas which is the granary of America has in fact some 26,000 sq. km. of salt belts beneath it.

The proposal for the Kansas Nuclear Park is sequel to the results of a study by a Committee on Radioactive Waste Disposal set up by the National Academy of Sciences—National Research Council of United States, nearly 15 years ago. The Committee reported that "the most promising method of disposal for high-level waste at the present time seems to be in salt deposits. Salt has many characteristics that make it particularly attractive for storing radioactive material.

Subsequent to this, the AEC's Oak Ridge National Laboratory carried out in 1965-67 a study known as "Project Salt Vault" in a mine near Lyons. This Project demonstrated the safety and feasibility of handling high radioactive wastes in an underground environment, determined the absence of detrimental radiation or heat effects on the salt, and provided engineering data permitting the initiation of the proposed full-scale demonstration project at Kansas Nuclear Park.

Long-term Storage

The purpose of the AEC's demonstration project will be to provide technical data and experience on operational methods and costs of long-term storage of solidified high-level wastes generated by commercial reprocessing plants which remove waste fission products from fuel used in nuclear power stations. In addition, the waste management facility will provide long-term storage of solid materials contaminated with low-level radiation, principally the trans-uranium elements such as plutonium generated at some installations.

The USAEC plans to initiate the project during 1972. It says the facility will be able to handle all of the commercial waste from nuclear energy used through the end of this century. It would take about 3 years to prepare the area. About 406 hectares will be required for the facility, 80 hectares for the mine itself, and 320 hectares in the adjacent unmined salt. According to USAEC experts, radioactive waste materials will be placed in rooms mined in the salt formations approximately 300 m. underground under conditions which will be perpetually safe.

— K. A. NEELAKANTAN

The Matrix of Development*

Nuclear Medicine in the Seventies

By Dr. Vikram A. Sarabhai
Chairman, Atomic Energy Commission

It is my purpose today to explain where we stand in nuclear medicine and outline a profile for the future which we would do well to commit ourselves to. There are many experts in nuclear medicine here in the audience, but there are also many non-specialists, who would be curious about the distinguishing features which have made this one of the most rapidly expanding fields of modern medicine.

Until artificial radioactivity was discovered by Rutherford in 1919, we were aware only of the high energy sub-atomic particles and wave radiation associated with cosmic rays and naturally occuring radioactive substances.

Valuable Properties

Most elements that naturally occur are stable. In other words, the atoms of these elements exhibit chemical properties which do not change with time. However, when these elements are bombarded by high energy radiation, such as neutrons from an atomic reactor or the beam of a high energy accelerator such as a cyclotron, every now and then an interaction occurs with the nucleus of the target element which gets transformed into an isotope, which has an atom of the same chemical element, but different mass, or an atom of a different element. These transformed nuclii are usually not stable and are called artificial radio nuclii. They emit other high energy radiations, just like those emitted by naturally occuring radium but their activity of emitting such radiation decays with a very characteristic time period measured in terms of their half life. It is this property which is most valuable in the wide applications of radio nuclii for medical diagnosis. For instance, I^{131} used widely for diseases of the thyroid has a half life of 8 days and Tc-99 (Technetium) has a half life of only 6.6 hours. Though short half lives present many special problems in the manufacture and distribution of radio pharmaceuticals, the great merit in their use lies in their selective absorption in different organs of the body and relatively little radiation burden imposed by them on the general system. While their activity lasts they provide unique information through radiation that they continue to emit after absorption in a particular normal or deceased organ of the body. The detection of the emitted radiation by external instruments is due to their great power of penetration. To put this matter in the correct perspective, let us note that while the quanta of X-rays have energy several tens of thousand times greater than invisible light, the gamma rays and the sub-atomic particles in radioactivity have several million times the energy of visible light.

The therapeutic use of radio pharmaceuticals is connected with the well-known effects of radiation on biological systems. Cobalt 60 with a half life of 5.3 years and Cesium-137 with a half life of 30 years are used in teletherapy units. 99% of all *in vivo* nuclear medicine procedures use Iodine-131.

Favourable Characteristics

Some of the most important advances in nuclear medicine in recent years have been rendered possible through the availability of Technetium-99m with its short half life. It is now considered almost an ideal radiopharmaceutical for a wide variety of applications. The very favourable nuclear characteristics of this isotope make it specially attractive for various diagnostic procedures.

Tc-99m is conveniently supplied through generators or milking units which consist of columns of chromatographic alumina on which the parent molybdenum-99 (half-life 67 hours) is firmly absorbed; Tc-99m is milked out of the column using dilute sodium chloride solution. The Tc-99m thus milked out can subsequently be converted into various chemical forms suitable for liver, spleen, lung, bone and placental scanning. The availability of such type of generators enables doctors located away from the production centres to use such short-lived isotopes in valuable diagnostic procedures.

Short Half-Life

For the production of Tc-99m generators based on chromatographic alumina, it is essential to have the starting material *i.e.* the parent molybdenum 99 with a specific activity exceeding one curie per gramme. For the production of such high specific activity molybdeum 99 in substantial quantities it is essential to irradiate natural molybdenum at neutron flux exceeding 3×10^{14} neutrons per cm^2 per second. It is not practicable to prepare these generators from low specific activity molybdenum as the product Tc-99m is likely to be contaminated with excessively large quantities of molybdenum. Alternatively Tc-99m can be made available in a pure form after separation from the parent, but the short half life restricts the availability of this product to institutions which are readily serviced from the production centre. A procedure has now been standardised at Trombay for the production of pure Tc-99m from low specific activity molybdenum 99 and routine production and supply of Tc-99m as a guaranteed radiopharmaceutical is expected to be taken up shortly.

Even though the first batch of indigenously produced radioisotopes from the Apsara reactor was released for medical use in 1958, routine production of several radiopharmaceuticals on

(Continued on page 4)

*Excerpted from the Bhabha Memorial Lecture of the Society of Nuclear Medicine, New Delhi, October 21, 1970.

Need for Major Initiatives in Nuclear Medicine

(Continued from page 3)

a fairly large scale was taken up at Trombay towards the end of 1963 with the start-up of the CIRUS reactor. At present more than 50 different radiopharmaceutical preparations are on the production list. Considering the range of products produced completely in India, we rank among the top five to six countries supplying radiopharmaceuticals in the world.

While significant progress has thus been made in the development and routine production of radiopharmaceuticals in this country, in the matter of their application in Nuclear Medicine, India has lagged way behind the advanced countries, and is even well behind some other developing countries. While there are about 65 medical institutions currently using radiopharmaceuticals in India, excepting three or four centres, all others are confined to thyroid uptake studies using radioiodide. In the United States of America about 40 million dollars worth of radiopharmaceuticals are consumed annually. In Japan, this figure is over 2.5 million dollars. In India, radiopharmaceuticals valued at only 80,000 dollars (5 lakhs rupees) were used in 1969.

From a modest number of 400 consignments in 1961 we reached a figure of over 10,000 consignments per annum in 1968 with a doubling time of approximately 2 years upto 1965. After this rapid progress there has been stagnation. This is not because the Nation's needs are fully met. Far from it. Let us for purposes of comparison examine the figures from other countries. Australia during 1967-68 carried out 5.6 investigations with radioisotopes per 1000 of population, Denmark 7.1, Japan 1.7, New Zealand 2.4, Sweden 6.1 and United States in 1966 a figure of 9.2. The corresponding figure for India is only about 0.05 per 1000 of population. There are at present about 80 medical radioisotope users in the country and among them there are perhaps only 2 or 3 institutions which account for more than 80 per cent of the consignments of radioisotopes.

Experience in Bombay

There is a possibility of drawing erroneous conclusions when we compare figures in India with those in industrially more developed nations enjoying a much higher standard of living. However, experience in Greater Bombay related to the Radiation Medicine Centre of the Bhabha Atomic Research Centre provides a good indication of what can be achieved at least in our metropolitan and urban areas. The number of investigations conducted per year per 1000 of population of Greater Bombay works out to 2, a figure comparable to Japan and New Zealand. We should note that the Centre is not merely a well-equipped clinic for nuclear medicine but undertakes training of doctors in various aspects of nuclear medicine and the Bombay University itself has recognised nuclear medicine as a speciality and has instituted a diploma in radiation medicine. A similar diploma for technicians has also been instituted.

Shortage of Equipment

Until recently little progress was made in this country in some of the most important areas of nuclear medicine such as scanning, primarily because of non-availability of adequate funds for scanners, ancillary electronic equipment and accessory facilities and infrastructure. The Electronics Corporation of India Ltd., a public sector enterprise of the Atomic Energy Commission is now marketing these. In the U.S.A. with a population of 200 million there were more than 6500 hospitals and licensed doctors using radiopharmaceuticals in 1969 with an average of 100 new nuclear medicine facilities being added each year. There were about 10,000 scanners and 300 scintillation cameras in use. In Japan with a population of 100 million, there are 3500 scanners. There are at present just 11 scanners in the whole of India and just one scintillation camera.

Taking all factors into consideration it is perhaps reasonable to aim by 1975 to provide a target of 2 investigations per thousand of urban population. This would involve approximately 100,000 investigations per year. Once the infra-structure is established, a doubling time of two years is quite reasonable, taking our past experience and that of other countries into consideration. On this basis we would need to provide for approximately 0.75 to one million investigations by 1980.

Following the style of the systems analyst let us examine what is involved in our being able to provide modern radiation medicine in this country on the scale envisaged. We can identify at least five major initiatives that would be needed.

First, we must ensure the availability of an adequate supply of radiopharmaceuticals at reasonable price. The starting up of our large power reactors during the next 3-4 years at Ranapratap Sagar and at Kalpakkam would give us the ability to produce about 3 million curies of radio cobalt annually. We shall also have the Variable Energy Cyclotron at Calcutta. This 80 MeV accelerator is under construction. But apart from the bulk supply of isotopes we would need chemical processing facilities and one such large unit is under construction at Trombay. At present the manufacture of radiopharmaceuticals is carried out on a very small scale at the Bhabha Atomic Research Centre and a large unit for dispensing and testing would be needed. The distribution of radio pharmaceuticals calls for special arrangements for transportation by airplanes with minimum hold-ups in transit and special precautions to be undertaken for handling the consignments. This needs effective coordination with civil aviation in this country.

Second, we should augment the availability from local manufacture of modern instruments as well as create a distribution and servicing

(Continued on page 8)

rems and mrems

Notes on sources of radiation and the amounts received by Man. Extracted from "Nuclear Energy and the Environment," published by the International Atomic Energy Agency, Vienna.

Natural sources

Man has always been subjected to natural radiation; his body contains natural radioactivity and when two men meet they are in effect irradiating each other. Indeed natural radiation induces mutations, one of the main factors that causes the evolution of living species. But excessive radiation injures human tissue and can cause cancers and genetic damage.

Natural radiation induces cosmic radiation; there are also naturally occurring radionuclides in the ground, air, sea, plants and animals, as well as in the human body. The levels of natural background radiation differ greatly in various parts of the world. The doses received from the ground differ considerably from place to place depending on the composition of the soil.

Man-made sources

In addition to natural sources of radiation, man is exposed to sources of radiation he himself has created. Man-made sources of radiation include the fall-out from nuclear bomb testing, radioactivity released in the course of nuclear power production, and ionizing radiation used for various medical and industrial purposes.

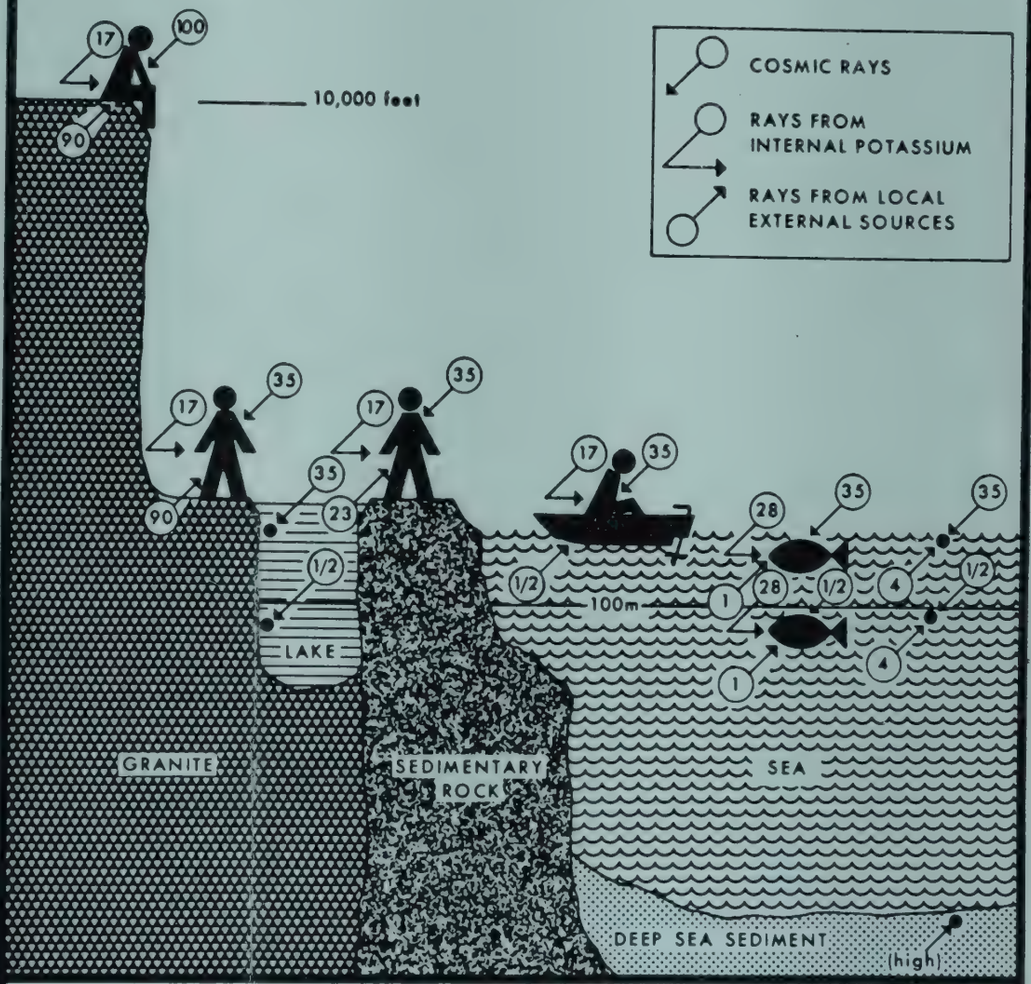
Nuclear weapons testing is the major source of man-made radioactive contamination of the environment (besides adding psychologically to the anxiety of many people about other applications of the atom). The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) periodically produces and updates reports on the levels of radioactive contamination throughout the world and the contribution that fall-out makes to such contamination. Since the conclusion of the partial Test-Ban Treaty in 1963, these levels have been decreasing.

Medical sources

Ionizing radiation is now one of the most valuable tools for research, diagnosis and treatment. The table given on p. 6 indicates that medical exposures,

natural radiation

Information from "The Effects of Atomic Radiation on Oceanography and Fisheries" NAS-NRC Pub 551/1957



TOTAL NATURAL DOSES (mrad/year)✓

Man over granite		Man over sedimentary rock	Man over sea	Large fish in sea		Micro-organism in sea	
10.000	m.s.l.			at surf.	100m	at surf.	100m
207	142	75	52	64	30	39	5

✓A mrad is one thousandth of a rad, the unit for indicating absorbed energy in tissues.

although many times larger than exposures resulting from all other peaceful uses of nuclear energy put together, are still only a quarter of the amounts received from natural radioactivity.

Average yearly dose to the population (information taken from the Report of UNSCEAR, 1962)

	Genetically significant dose (mrem)
Natural radiation	125
Medical exposure:	
Diagnostic	30
Therapeutic	5
Occupational and miscellaneous exposure including all peaceful uses of atomic energy except medical	2

One mrem is one-thousandth of a rem, the unit of ionizing radiation giving the same biological effect as that due to one roentgen of X-rays (thus Roentgen Equivalent Man)

The International Commission on Radiation Protection (ICRP) has set a recommendation for the genetic dose to the population as a whole over a period of thirty years with respect to exposures other than by natural radiation and by medical treatment. This must not exceed 5000 mrem over the period. Generally this means that all exposures except those from natural background and medical applications should not contribute on average more than 170 mrem per year. Present exposure is only about one quarter per cent of this figure.

The ICRP has also recommended dose limits for the individual members of the public to guard against harmful effects. Whether the individual dose limit or the genetic dose is overriding depends on many factors which are beyond the scope of this discussion and it is enough to say that the number of people exposed is a very significant factor. However, the highest degree of exposure to people living in the vicinity of a reactor is only a few tenths of the dose limits permitted. ●

Progress and Its Price

CIVILIZATION depends largely on man's ability to change and control his natural environment—and thus on the energy at his disposal. Until the industrial revolution, man depended mainly on his own hands and his domestic animals, but in the last two centuries the tempo of man-made environmental change has constantly quickened.

For almost every new benefit of technology, some price has had to be paid in terms of environmental side effects. In the first century of the industrial revolution, smoke and grime poured from the chimneys of the new foundries, factories and gas works. Industrial progress has helped to clear the air of some of these pollutants but has also brought new ones in their stead.

Noxious Gases

If man's standard of living is to go on rising and if the rapidly growing population of the world is to be properly fed, housed and clothed, the tempo of environmental change will increase even further. The "green revolution" that now brings record crops depends on the use of artificial fertilizers, but when these are washed away into rivers and the sea they may upset the balance of nature. Chemical insecticides like DDT are indispensable for protecting crops and for combating diseases, but their harmful side effects are causing growing concern. Detergents ease the burden of labour, but their cumulative effect is the pollution of rivers into which they are eventually drained. There are now about 200,000,000 motor cars on the road : on average each one discharges almost a ton of noxious exhaust gases each year (more than 700 kg of carbon monoxide, 100 kg of hydrocarbons and 35 kg of oxides of nitrogen). The burning of fossil fuel by industry and automobiles is steadily adding carbon dioxide to the atmosphere and causing fears of a gradual change in the earth's temperature which could have drastic climatic consequences. We have come to depend on oil for power and gasoline and kerosene for transport, but we have also seen the damage that can be done to the sea and its wild-life when super tankers founder or when oil wells leak.

Stockholm Meet

Until quite recently, most countries were relatively heedless of the long-term damage that new industry and technology might be doing to the environment. The cost of minimizing harmful side effects was a price that society was unwilling, and perhaps often unable, to pay. The findings of science itself have made us all much more aware of the environmental consequences of material progress and of our responsibility to preserve not only our particular national heritage, but the entire planet as a place to live in for future generations. For several years international bodies such as the World Health Organization (WHO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Economic Commission for Europe (ECE), and the Council of Europe, as well as public and private national bodies, have been calling attention to the problem. World-wide concern has led the United Nations to convene the first major international conference on the human environment in Stockholm in 1972.

Nuclear Energy

Cheap and plentiful energy leads to industrial progress and better living standards. The per capita consumption of electricity has proven one of the best indices of the degree of technical development in a country. In the next thirty years man will use as much energy as he has since he appeared on earth. Energy consumption in the year 2000 will be about four times as high as in 1970. In

(Continued on page 7)

most countries electricity production for the home and farm, as well as the factory, doubles every ten years; in many the doubling period is even shorter. Yet, even now, two billion out of the world's three, have no electricity. Asia, with half the world's population, produces only one-tenth of its electric power.

For many reasons nuclear power will be called upon to help meet man's energy needs. Firstly, the reserves of fossil fuels (oil, coal, gas) are not unlimited. They also represent valuable raw materials for future generations and should not be burned up heedlessly. Uranium resources in the world, if used as fuel in advanced reactor types, contain more energy than presently known reserves of fossil fuels. Controlled nuclear fusion, if it is achieved, would meet the world's energy requirements for an indefinite future.

The release of smoke, soot and corrosive gases from fossil-fuelled plants has become a serious problem in highly developed urban areas. A large coal-fired power station of 350 MW(e) emits about 75 tons of sulphur dioxide, 16 tons of nitrogen oxide and 5 tons of ash particles each day. Nuclear power provides a relatively clean alternative. By 1980 nuclear energy is expected to provide 13% of the world's electric generating capacity; by the year 2000 about 50%. Nuclear energy is also used to treat, diagnose and prevent disease, to lower the cost and improve the quality of a widening variety of manufactured goods, and to increase production as well as reduce wastage of food. In time, nuclear energy may be used to desalt water by the use of large reactors or to expand our natural resources by the use of nuclear explosives. If its price falls far enough it may begin to supplant coal and coke in the steel and other metallurgical industries.

Like most other technologies, nuclear power has certain environmental side effects. The wastes of nuclear energy plants are chiefly radioactive products, some of which are valuable and can be used, for instance, for sterilization purposes. The rest of the wastes must be managed through storage or controlled disposal. Some radioactive wastes are long-lived and have to be isolated for long periods of time. Operation of all the plants associated with nuclear power results in discharge of radioactivity, but the dose to the public is trivial.

Nuclear Waste and Its Treatment

Nuclear power plants use uranium in one form or another as their fuel. After mining, uranium passes through several processes of concentration, refinement and conversion before it can be used in a reactor. For the modern plants at present in most common use, though not for natural uranium/heavy water reactors, it is also necessary to "enrich" the natural uranium slightly, that is to say increase the ratio between the fissionable isotope (uranium 235) and the 140 times more plentiful isotope (uranium 238). Today this enrichment is performed in a few vast and complex gaseous diffusion plants in five countries. Normally, the enriched uranium produced by these plants is then chemically processed into oxide powder and fabricated into fuel elements, *i.e.* sintered, pressed into pellets and "clad" in a gas-tight metal tubing. A number of fuel elements are combined into an assembly for loading into the power reactor.

Recycling the fuel

After the power reactor has been in operation for a certain time the fuel element contains various radioactive fission products and plutonium as well as uranium 238 and uranium 235. All these fission products and the other constituents are of course essentially retained within the protective cladding during exposure of the fuel element in the reactor. The fuel element is then taken to a special plant where the remaining uranium 235 together with the plutonium and the uranium 238, are purified and recovered by "reprocessing." They can then be used in new fuel elements. For this purpose they are usually returned to a fuel element fabrication plant.

Managing the wastes

Radioactive waste is produced and some is released at most stages in the fuel cycle:

Mining and refining operations;
Fuel fabrication plants;
Nuclear power plants;
Reprocessing plants.

For technical reasons the main waste products to be dealt with in refining uranium ore are radium and radon.

In fuel fabrication most of the waste consists of shavings and particles of natural or enriched uranium. These are valuable and are usually collected and put back into the fabrication process.

Although the new radioactive products are created during the reactor's operation, the amounts which reach the environment are so limited that they cannot cause any hazards, even through accumulation in living organisms. More than 99.9 per cent of the radioactive products are separated at the following stage in the reprocessing plant, as solids, liquids or gases. It is therefore at this stage that the main task of radioactive waste management begins.

The objective is to keep these potentially dangerous wastes isolated from man and his environment. The first step is to store the waste, nearly all of which is in liquid form, for a long period during which it loses most of its radioactivity. A gas that has a long radioactive half-life — krypton 85 — is released in reprocessing plants, but in the present scale of nuclear programmes causes no health or genetic hazards. Eventually it may be necessary to separate and store this gas for radioactive decay.

After initial storage, these liquid wastes are chemically or physically treated often by solidifying them so that they may be safely stored in underground or other inaccessible locations (for instance, in guarded caves, disused mines or the deep ocean). *(Extracted from "Nuclear Energy and the Environment" published by the IAEA, Vienna.)* ●

Nuclear Medicine in the Seventies

(Continued from page 4)

organisation to maintain them in good order.

Personnel

Third, we need more programmes for the training of Doctors and Technicians. In providing them specialised institutions such as the Radiation Medicine Centre of the Atomic Energy Commission would have a very important role to play. So also can training be given at selected medical college hospitals. With about 80 medical users of radioisotopes, we will have to have as many as 1500 persons both medical and para-medical to be trained in the medical applications of radioisotopes.

Fourth, one would need the establishment of an adequate number of units for radiation medicine in public hospitals and private clinics. This could be achieved by establishing a number of small radioisotope laboratories which are supported by a few large centres. There are at present 95 medical college hospitals in India concerned with undergraduate and postgraduate medical education distributed among the various States. This figure will increase to 105 by the end of the IVth Plan. Setting up of small radioisotope laboratories in each of these medical institutions would serve a large cross-section of at least the urban population and also provide an unique opportunity for training of the medical and para-medical personnel attached to these institutions. It is estimated that a small radioisotope laboratory can carry out about 5000 radioisotopic investigations per year and commissioning of 105 radioisotope laboratories, though a phased programme would, by 1980, ensure a substantial coverage. The small radioisotope laboratories in the various medical institutions proposed above, require to be supported by regional or zonal institutions which by their facilities and inter-disciplinary representation among the staff, would be in a position to provide such of those advanced techniques in diagnosis and treatment which would not be possible at the peripheral radioisotope laboratories in the region, and also be responsible for carrying out research in problems peculiar to the region. Such institutions will have a multiplier effect on the overall development and progress of medicine at the national level. There would be need for an advisory service run by the Atomic Energy Commission to assist the setting up of these clinics and for special technical information which may be required.

Finally there would arise a need for radiation protection of the workers engaged in the expanded programme of radiation medicine. We are already well established to undertake this through the Directorate of Radiation Protection of the Atomic Energy Commission.

With the availability of high activity radio cobalt from our atomic power stations, we shall be able to augment in two years the supply of indigenous teletherapy units to satisfy the large demand which exists today. India has currently only 45 teletherapy units against about 600 in Japan and about 1500 in the United States.

Plant at Trombay

An important application of Cobalt 60 in the field of medicine is for the radiation sterilisation of medical products like sutures, disposable syringes and surgical dressings. A large facility for radiation sterilisation is now being planned with assistance from the U.N.D.P. It is expected that by the end of 1972 or early 1973, a plant will be operating at Trombay and will serve to sterilise medical products manufactured in the Bombay area. The capacity of this plant will be progressively stepped up to cater to requirements upto a maximum of 1 million cubic feet per year. It is also proposed to set up 3 other large sterilisation plants in the plan period in other regions in the country, where market surveys reveal a demand for such sterilised products. These facilities will serve to upgrade the quality of medical products available in the country.

I have discussed today many practical applications of radioisotopes. If India is to be amongst the advanced nations in the world in the field of radiation medicine, our effort will have to be supported by a very major programme of basic research. Radioisotopes have now made it possible to understand living processes in dynamic terms. A quantitative analysis of the intermediate steps operative in homeostates is possible with the help of this modern tool. Prior to the advent of radioisotopes, a majority of the conventional diagnostic aids were either static bits of information in established diseases or were more in the nature of confirmation of a clinically suspected condition. The results of such investigations generally failed to provide a comprehensive picture of the processes leading to the diseased state.

Advanced biological and medical research would receive a great stimulus from an active programme dealing not only with radiation medicine but all the five elements listed earlier by me as the ingredients of development in this field. ●

SYMPOSIUM ON ELECTRONICS 1971

Venue : Indian Institute of Technology, Madras

Dates : February 25, 26 and 27

Last date for receiving abstracts and papers January 1, 1970

Topics to be covered :

1. Digital Electronics
2. Solid State Electronics
3. Instrumentation.

Abstracts and papers should be sent to Professor S. Sampath, Deputy Director, IIT, Madras.

For further details please contact Dr. P.V.S. Rao, Tata Institute of Fundamental Research, Bombay-5.

Edited and published by Jagannath Sharma, Publications Officer, Dept of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 1, and printed by him at Conway Pvt. Ltd. (Printers), 6, Tulloch Road, Bombay 1.

Registered No. R.N. 9002/62

NUCLEAR INDIA

VOL. 9. NO. 4 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY DECEMBER 1970

Double Fluted Tubes for Desalination Plants

AS part of its efforts toward developing desalination technology, the Bhabha Atomic Research Centre at Trombay has successfully fabricated double fluted tubes (see picture) which form an important component of desalination plants using advanced distillation techniques.

Because of their large surface area, double fluted tubes have a greater heat transfer efficiency, a property of importance in the evaporator system of the plants. The number of DF tubes required is therefore very much less than the ordinary smooth ones.

Capital Investment

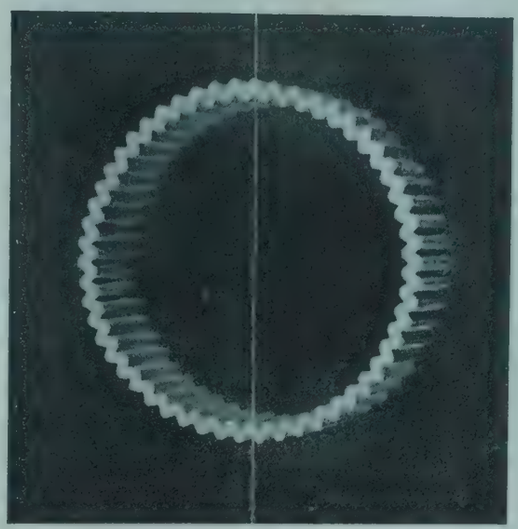
At present, DF tubes are being made only in limited numbers by some firms abroad (the knowhow for their fabrication incidentally is of a proprietary nature). At BARC the tubes were fabricated by the Atomic Fuels Division in collaboration with the Waste Treatment Division.

Twenty-five units, each having an overall length of 1296 mm have been made so far. The fluted length is 992 mm. A length of 152 mm at both ends is plain.

The use of DF tubes would reduce the capital investment on desalination plants considerably. It has been estimated that the investment on a 225

See also page 4

million-litres-a-day plant (with DF tubes) would be around Rs. 21.21 crores against Rs. 29.85 crores with smooth tubes. The cost comes down from Rs. 10.95 crores (36.68 per cent of the total investment) with smooth tubes to Rs. 6 crores (28.29 per cent) with the use of DF tubes.

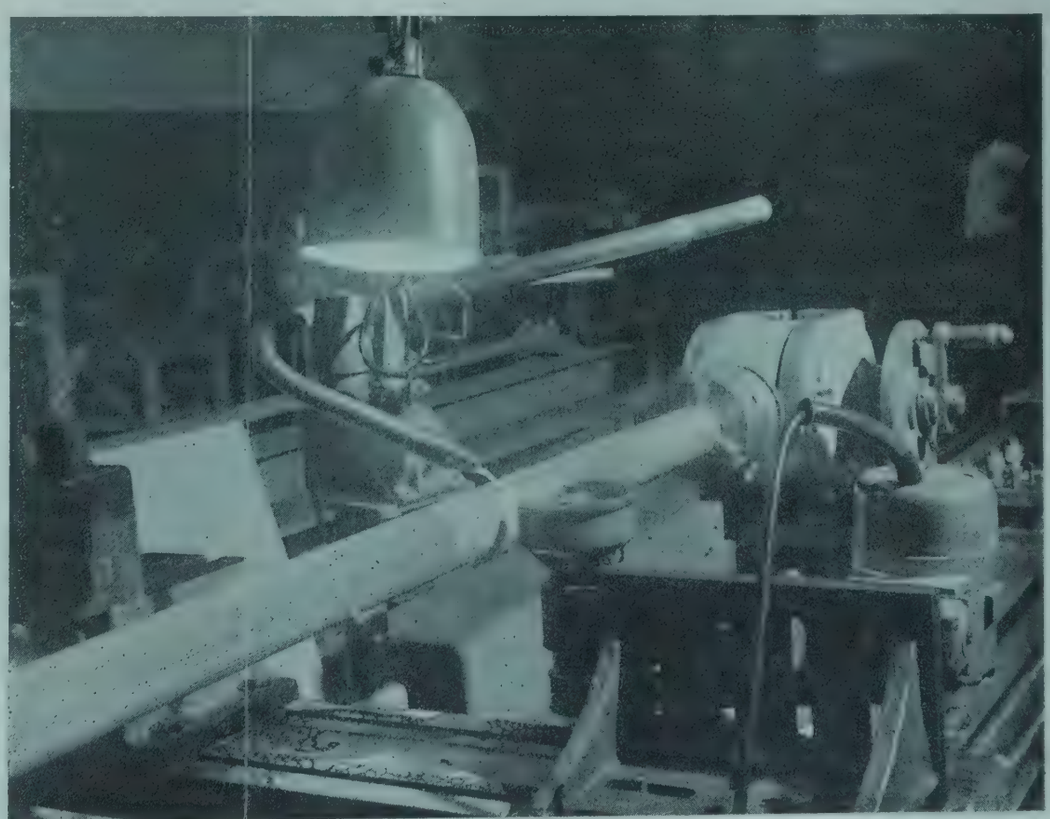


Above. A cross section of the DF tube. Below. Indigenously developed special extrusion tooling and double angle milling cutters for fabricating the tubes.

As the tubes are all made of an alloy of copper and nickel (both of which are imported), there would be considerable reduction in foreign exchange requirements both because of the lesser number required and also because of their fabrication in the country.

Commercially Feasible

The production and use of double fluted tubes is still in an experimental stage even in advanced countries and, except for a few small units, large scale commercial plants using such tubes are yet to be designed and constructed. However it is felt that double fluted tubes may revolutionise desalting technology and make wide application of desalination a commercially feasible proposition. ●



Desalination

(Continued from page 5)

desalination lies in their potential for providing large blocks of low-cost energy with the scale-up of plants to large sizes. Since the commissioning of the first power reactor at Calder Hall fourteen years ago, nuclear technology has come very far. The development of breeder reactors in the next decade or so, besides bringing down costs still further, will open up the energy locked up in the large reserves of thorium in India. Whereas developments in nuclear technology will provide an economic source of energy for large scale desalination, the developments in desalination itself are expected to bring down considerably the energy requirement of desalination, and the capital cost of the desalting plants. In view of cost reductions expected in large size nuclear dual-purpose plants, a number of studies including proposals for construction of plants having capacities as large as 2000 MWe of power and 4550 million litres per day of desalted water have been carried out in the USA. And in the Soviet Union a nuclear dual-purpose plant using a fast breeder reactor is already under construction on the Caspian Sea. This plant will generate 150 MWe of power and produce about 177 million litres per day of fresh water.

Additional Advantage

The cost of water from the dual purpose nuclear power plant producing 400 MWe of saleable power and 455 million litres per day of fresh water is estimated at about Re. 1/ cu. metre. It is expected that the use of advanced desalination processes like the LTVE-MSF process will reduce the cost to about 66 paise/ cu. metre. It has been estimated that scaling-up of capacities still higher may reduce the cost of desalted water to a figure comparable to the cost of municipal water in Bombay. An additional advantage of desalted water is that it can be used without any further treatment, for industrial processes whereas the water available from conventional sources has to be pretreated for such uses.

In arid and semi-arid regions and coastal metropolitan areas of the country where the need for water is high, desalination has great prospects. In certain inland backwater areas where available water is unusable due to brackishness, desalting processes can be usefully employed.

It is quite possible that in the not-too-distant future, desalted water can be produced at reasonable cost.

Nuclear desalination is expected to play a major role in this respect and significant cost reductions are expected both in power generation and water production using advanced concepts in nuclear and desalination technologies.

BARC Reporting

Isotope Division

A compact irradiation unit, Gamma Chamber-4000 with an irradiation volume of about 4 litres has been fabricated indigenously and 3500 curies of cobalt-60 have been loaded into the unit. This unit is to be supplied to the IAEA for its technical assistance activities in Uruguay.

* * *

It is proposed to set up a Gamma Chamber-900 unit at the Central Institute of Fisheries Technology, Veraval, Gujarat, for feasibility studies pertaining to radiation preservation of fresh fish. The source strength of this unit will be 2500 curie of cobalt-60.

* * *

A total of 2485 consignments including 2142 for medical use were despatched to outside parties during November 16 — December 15, 1970. The sale value of isotopes including equipment and services rendered during this period totalled Rs. 1.84 lakhs. A total of 590 consignments valued at Rs. 27,639 were exported to Argentina, Australia, Columbia, Indonesia, Kenya and Mexico.

Seminar on N

A THREE-WEEK seminar on the preparation of input for the International Nuclear Information System (INIS) concluded at the Bhabha Atomic Research Centre, Trombay on December 11.

Sponsored by the International Atomic Energy Agency (IAEA), Vienna, and hosted by the Department of Atomic Energy, the Seminar was designed to acquaint participants with the principles of input preparation for the computer based INIS which went into operation in May 1970 at Vienna. There were 32 participants from 7 countries in South-East Asia and the Far East and the USA besides ten observers.

The INIS is an information system set up by IAEA to help those interested in nuclear science and technology to keep abreast of developments in their fields.

Speaking on behalf of the IAEA Director-General at the opening ceremony on November 23, Dr. M. H. Binggeli of the IAEA Division of Scientific and Technical Information said INIS was the first international computerized, document-based system to work with input prepared in different countries for collation, processing, and distribution via IAEA headquarters in Vienna. And the Trombay regional seminar on input preparation for INIS was the first of its kind.

Enormous Literature

"We are involved in a world-wide experiment in gathering and processing information on a particular area of knowledge, vast in itself—that involving nuclear science and the peaceful applications of nuclear energy," she said. "In our nuclear age, projects are being set up on an industrial, technological or scientific scale, at great cost to the national economy. The by-products in terms of technical literature are enormous.

"With INIS, new information will be collected and catalogued just once. INIS will be capable of providing a far greater variety of output services than conventional systems, and many

of these new services will be tailored to the needs of individuals or groups of scientists and technologists."

Shri H. N. Sethna, Director of the Bhabha Atomic Research Centre in his inaugural address said : "The establishment of INIS, though restricted to the comparatively new and small, but vitally important field of nuclear science and technology, is a step in the right direction. The fact that some 38 nations have already joined the INIS within 7 months of its going into operation is indicative of the growing realization of its importance and usefulness among the nations of the world."

Shri Sethna disclosed that a survey made by the Technical Information Section of BARC revealed that during the last three years, on an average some 12,000 papers, reports, patents etc., of a scientific and technical nature were annually produced in India and the number was increasing fast. Of these, about 3,000 items fell within the full subject-scope of INIS *i.e.* approximately three per cent of the nuclear literature produced in the world.

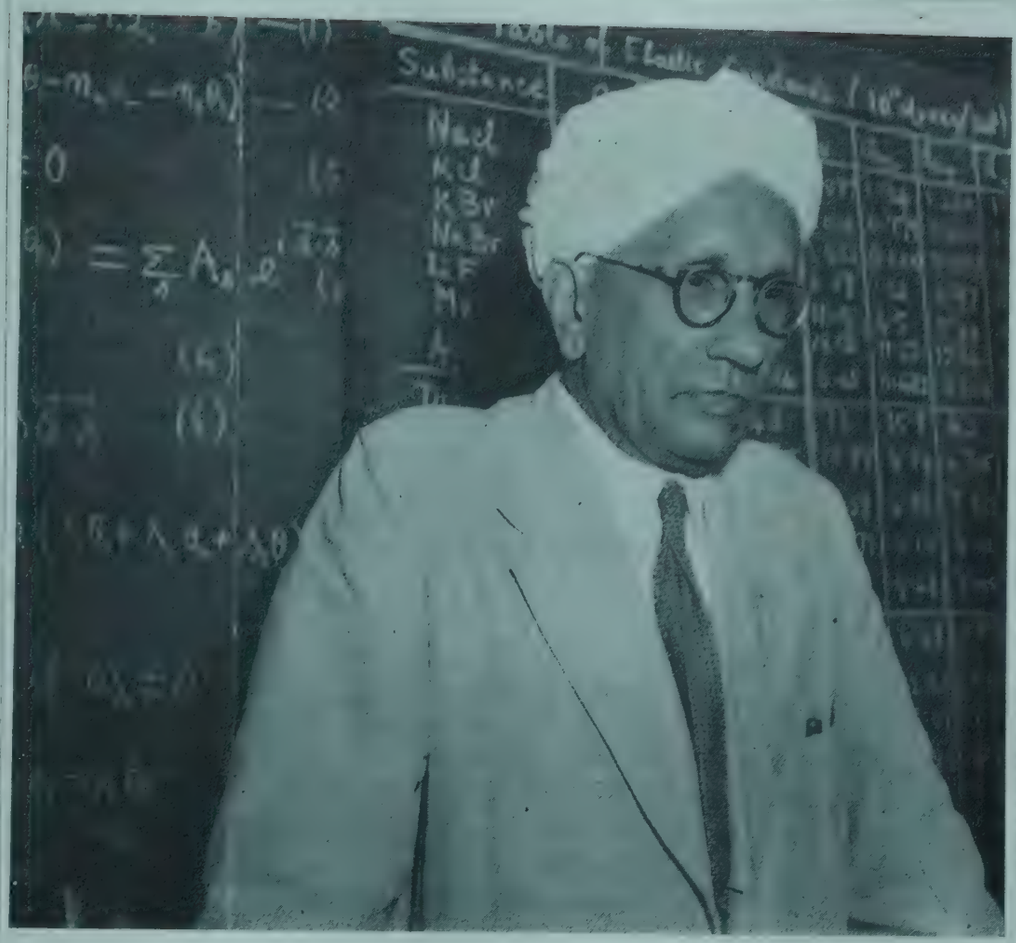
In his welcome address, Dr. A. R. Gopal-Ayengar, Director of the Bio-Medical Group and Chairman, Library Committee of BARC said India was one of the first countries to join INIS and had been regularly sending its inputs to the System.

Input from India

To convey an idea of the task involved in feeding INIS, Dr. Gopal-Ayengar said in the first instance, information had to be collected periodically about the papers published in Indian journals, presented at various symposia, conferences etc. in India, technical and scientific reports including those brought out by over 150 scientific and technical institutions, IITs and universities in the country, and examining them to see whether they fell within the subject-scope of INIS. Then there was the regular scanning of some 700 Indian scientific and technical journals done in collaboration with the Indian National Scientific Documentation Centre in New Delhi. Dr. Gopal-Ayengar said that nearly 4 per cent of the input fed into INIS so far was from India.

Attendance at this regional seminar was limited to a relatively small number, so that working groups could derive full benefit from its sessions. Participants were trained in all the stages of preparing inputs for INIS.

Those taking part in the seminar came from Australia, India, Indonesia, Japan, Korea, the Philippines, Thailand and the USA; and from the Federation Internationale de Documentation (FID). ●



'He Added a New Dimension to Scientific Life'

India has lost its greatest scientist in the passing away of Professor Chandrasekhara Venkata Raman. He provided a most vital inspiration to me as to countless others who had the good fortune to come in contact with him as students and as colleagues. His child-like curiosity for nature and a great sympathy for all those who shared his love distinguish him from many other great scientists. The Nobel Prize awarded to him was in recognition of his outstanding discoveries in the Scattering of Light.

Physics is one of the few disciplines in which we have reached an international level of excellence. This is largely through the untiring dedication of Prof. Raman to the maintenance of the highest standards, and the example which he set of independence, self-reliance and originality. In founding and nurturing the Indian Academy of Sciences, he added a new dimension to the quality of scientific life in this country. We can remember him best by constantly examining our contemporary actions and initiatives in the field of Science and Technology in terms of his values.

Dr. Vikram A. Sarabhai
Chairman, Atomic Energy Commission

Desalination : A Process f

WATER presents a paradox. It covers 71 per cent of the earth's surface yet there is not enough of it for man, because not all of it is readily potable or fit for industrial and agricultural use. Fresh water on the other hand is either limited, inaccessible or not available at the right time and rate in many areas. To meet the needs of a growing population and the consequent expansion of industrial and agricultural activity, the sea affords a solution—desalination plants could supplement traditional sources in many areas.

Desalination is a proven process. There are many desalination processes such as distillation, electrodialysis.

By K. T. THOMAS
Head, Desalination & Effluent Engineering Division, Bhabha Atomic Research Centre.

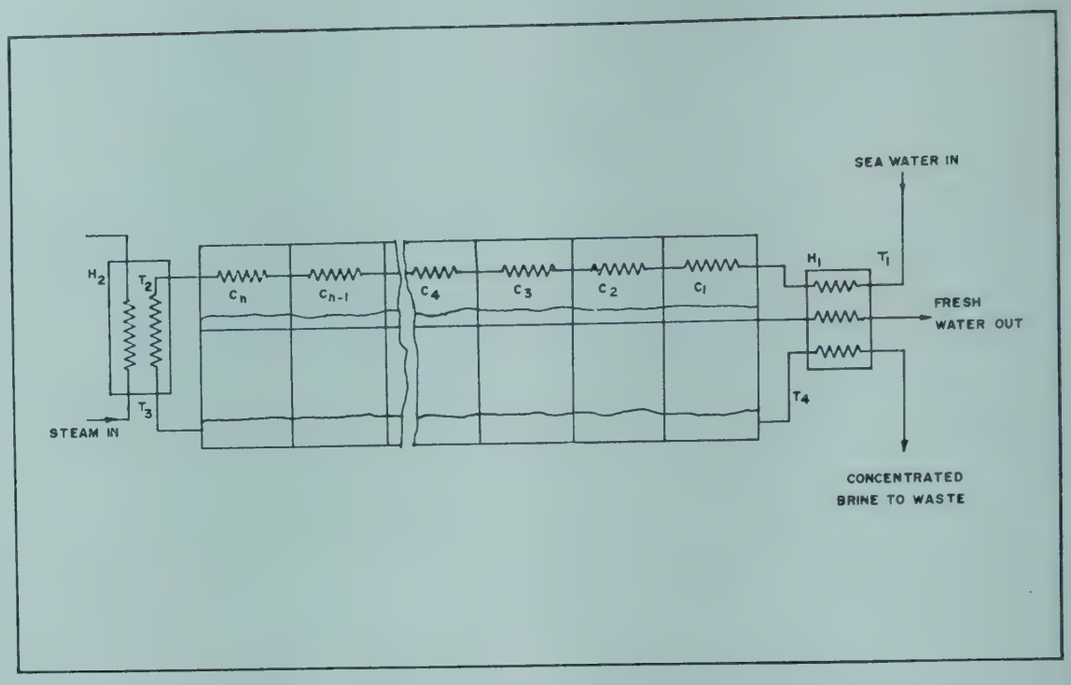


FIG. I. SCHEMATIC FLOW DIAGRAM OF A MULTI STAGE FLASH EVAPORATOR PLANT.

freezing and reverse osmosis available. The problem is how to work these processes at low cost. Even though well over 900 million litres of fresh water are presently being produced daily in different parts of the world through desalination, the cost of the water is high. This cost factor restricts the use of desalination mainly to places where conventional sources are practically nonexistent.

There are several basically different methods by which fresh water can be obtained from saline water. In only two of these is salt removed from water; in all the others, part of the water is extracted from the saline solution, leaving a more saline residue. Some of the processes are summarised here :

(a) **Distillation :** In this, saline water is boiled and the steam is condensed to yield fresh water. Thermal energy must be supplied, the quantity required being almost unaffected by the salinity of the original water.

(b) **Freezing :** Cooling the saline water till pure ice crystallizes and separates from the salty water.

(c) **Solvent Extraction :** This process involves contacting the saline solution with an organic liquid which dissolves water but not salt, separating the organic liquid from the residual saline water and later, recovering fresh water by heating the organic liquid. The solvent commonly used is triethylamine.

(d) **Hydrate Process :** A number of organic chemicals such as propane can combine with water to form insoluble crystalline compounds known as gas hydrates. The crystals are filtered off and heated to decompose the solid hydrate into fresh water and organic material, which is reused.

(e) **Reverse Osmosis :** Reverse osmosis involves the pumping of saline water under high pressure through a membrane which allows water to pass through, but is impervious to the dissolved salts. Mechanical energy is consumed, the amount depending on the feed water salinity.

(f) **Electrodialysis :** In this case, an electric current is passed through saline water in a cell containing alternate membranes of two different polarities. As a result, the salt concentrations are depleted in alternate compartments of the cell and concentrated in the other, and fresh water of the desired purity is withdrawn from the former. The electric energy consumed is proportional to the amount of salt removed from brine.

(g) **Ion Exchange :** In the ion exchange process, saline water is passed through two beds of resins, one of which removes the anions in solution and the other the cations, so that pure water emerges from the second bed. After some time, the beds become exhausted when they are regenerated by treating the cation resin with strong acid solution and the anion bed with strong alkali solution. The amount of chemicals consumed is proportional to the amount of salinity removed from the feed water.

Of all these processes, distillation is the most advanced one at present. The development of large distillation plants started in the early Fifties and the progress with respect to both installed capacity and technological development has been very fast. Distillation is the only process being considered at present for large-scale desalination, especially where sea water forms the feed. Considerable cost reductions are expected by using this process in future dual purpose plants. The feasibility of setting up large size plants and production of fresh water at a much lower cost than from other desalination processes has made this process most attractive.

he Future

Though a number of developments have taken place in other desalination processes also, their use has been restricted mainly to small size plants and to feed-water containing low concentrations of salts.

In the various distillation processes available, the most technologically developed at present is the Multi-Stage Flash process (MSF). The first plant based on the MSF process was built in Kuwait in 1957 and several plants have been constructed since.

The multi-stage flash system is represented schematically in Fig. 1. The heat supplied provides only the temperature differential required for heat transfer in the stages, rather than the latent heat of evaporation. The brine reaches its highest temperature after passing through the brine heater and enters the first flash chamber in which pressure is reduced so that the brine boils. The steam released is condensed on the tubes carrying the incoming brine. The desired pressure is maintained in each chamber by the condensing action of the heat exchangers. Only a small fraction of the water entering a given chamber can be evaporated in that chamber unless the temperature differential across the chamber is large. The rest of the brine passes on to the next stage at a lower temperature.

This process however has some built-in limitations thereby requiring large surface areas and consumption of energy. This has led to the development of multi-effect long tube vertical evaporators (LTVE) which are potentially more efficient. Some of the advantages of LTVE are :

(a) reduction in formation of mineral scales on heat transfer surfaces.

(b) increased efficiency due to better thermodynamic reversibility; and

(c) reduced size of equipment and less consumption of pumping energy due to low volume of circulated brine.

To improve the LTVE process further and to make it feasible for large scale applications by reducing large investments and operational and maintenance requirements, the vertical evaporators can be used in conjunction with the multi-stage flash process, the latter acting as a preheater for the incoming sea water feed. Such a combination, popularly known as LTVE-MSF process, would reduce the need for too many inter-effect pumps. A scheme of this process is given in figure 2.

In the design of this system about 75 per cent of the input heat is directed to the first vertical tube. This steam condenses on the outside surface of the tubes and the heat so given up causes the sea water flowing down the inside of the tubes to evaporate. This heat is used in the second effect which is at a lower pressure so that the brine in this stage boils at a slightly lower temperature. The residual brine from each effect separates from the vapour and is returned to an appropriate stage of the MSF preheater section.

The remaining 25 per cent of the input heat is used to provide thermal energy for the final stage of sea-water preheating. The initial sea water preheating is carried out in an MSF evaporator integrally connected to and operated in parallel with the LTVE. This MSF section produces about 15 per cent of the product water.

Recent developments in the multi-effect process are the use of enhanced heat transfer tubes such as the double-fluted and spirally corrugated tubes. (see page 1.)

As has been mentioned before, distillation is the most economic process today for the production of large quantities of fresh water, especially when the salinity is high. The process requires a large amount of low pressure steam which can be obtained at a cheap rate by combining a power plant with a desalination plant. The production of electrical power can be more efficiently accomplished with high temperature and high pressure steam. On the other hand desalination plants cannot use steam above 260°F because of scale formation on heat transfer surfaces. Thus, by combining the two processes, that is, producing power from the higher temperature section and placing a distillation plant in the lower temperature portion, thermal energy can be used more effectively. Additional savings could be made as facilities like sea water intake and reject, site development and integrated maintenance and operation staff are shared.

If one considers the feasibility of producing large quantities of low-cost desalinated water, nuclear energy appears to be the only answer. The incentive for use of nuclear reactors for

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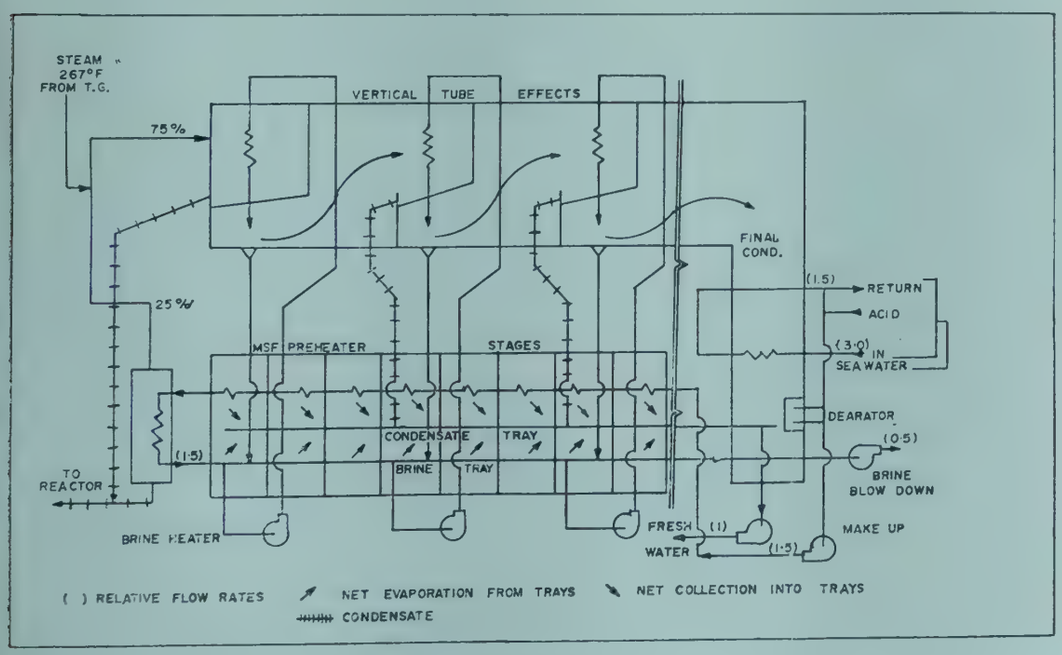


FIG. 2 SCHEMATIC FLOW DIAGRAM OF MSF-LTVE PLANT

NIMBUS

By Angela Croome

(reprinted from "Spectrum" No. 78)

There are several difficulties in accurately forecasting the weather. One of them is that the atmosphere is three-dimensional and another is that the weather is "created" often miles from where it is happening. Scientists believe that measurements from satellites could overcome both these problems. A key feature of the mixing of the atmosphere on which "weather" depends is the differences in temperature of the air at various levels above the ground. The importance of the "high weather" has also become a practical matter with the increase in jet flying at great altitudes.

AS long ago as 1960, scientists at the two neighbouring universities of Reading and Oxford in England, began to put their heads together on how to make useful measurements of meteorological phenomena from orbiting space vehicles. The groups were led by Dr S. D. Smith (at Reading) and Dr John Houghton at Oxford. It was a fruitful collaboration. Houghton and his group provided the meteorological knowledge; Smith and his team were experts in instrumentation and, in particular, infra-red optics. The radiation given off in the infra-red is the obvious method of measuring sources of heat in the atmosphere from a satellite, and infra-red detectors of various designs have in the recent past been used to tell the surface temperature of Mars and its atmosphere.

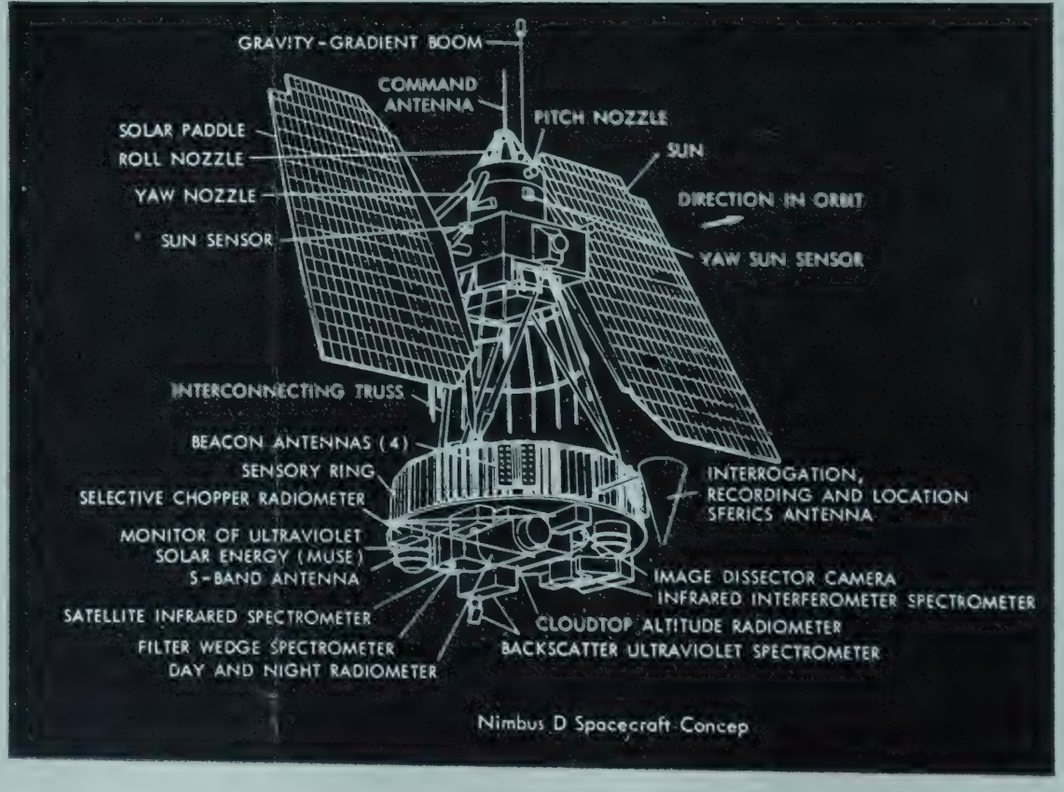
The importance of the Houghton-Smith atmospheric temperature measuring instrument is the enormous volumes of accurate data it is able to obtain. The first one to fly in a satellite was launched on April 8 this year aboard one of the American National Aeronautics and Space Administration (NASA) Nimbus advanced weather satellites. On successfully reaching its 1100 km high circular polar orbit it was officially called Nimbus 4. The instrument was soon proving such a success that by the beginning of June the United States Weather Bureau was asking if it could have access to the data.

Greater Range

So, since June 25, 1970 almost exactly midsummer, data from the Houghton-Smith experiment aboard Nimbus 4 has been contributing to the daily analyses of the US Weather Bureau. At the beginning of the satellite's life, data from an American instrumented temperature measuring experiment had been supplied to the US Weather Bureau. The British data replaced this as of midsummer. In the first instance, the American instrument's "voice" became unacceptably noisy on the telemetry link so that it became increasingly difficult to make any sense of the signals being received. But there were other advantages. The Houghton-Smith experiment reaches from 5 km up to 45 km whereas the American range reached little more than half this height. Moreover the resolution was about twice as accurate as that of the American data. It has now been announced that the technique pioneered by the Houghton-Smith experiment on Nimbus 4 is to be adopted for all future vertical soundings of the atmosphere from both the Tiros and Nimbus series of satellites, and a similar system is in view as the main experiment (by the Meteorological Office) on the planned second satellite, X-4, in the British Black Arrow programme.

In the Nimbus 4 version the experiment for the first time gives a vertical chart of the atmosphere's temperature to well above current jet heights (45 km). The readings are accurate to 1°C. The whole globe's atmospheric temperature at 6 different altitudes is scanned twice a day as the Earth turns beneath the Polar-orbiting spacecraft. Each orbit's data is stored on a tape-recorder and then read out and registered at each pass at a ground-station in Alaska whence it is relayed through Washington to the two universities in England. Information on conditions over the oceanic areas on the other side of the world where there are no standard measurements are available in Washington within six hours.

General view of the Nimbus 4 satellite indicating general layout of the system. It is stabilized so that the bottom end is permanently Earth-facing.



The data, which is computer processed, is able to show up by inference clouds and storms which occur where there are no regular radio-sonde measurements, such as over oceans and the Antarctic. Later it is expected to "see" the arrival of a good summer some months in advance — such as that experienced in the Northern Hemisphere this year. This is thought to start with an early warming high in the atmosphere, detectable at present only from space vehicles. Nimbus 4's April launch was too late to predict this year's good summer.

Atmospheric temperature measurements are made by looking at the infra-red radiation travelling vertically up to the satellite in a 500-mile-high circular polar orbit. Key to the British experimental success has been the ingenious design of the radiometer, employing a selective chopping technique. The detector aboard the spacecraft consists of a carbon-dioxide (CO_2) cell the size of a penny acting as a lens for filtering the incoming atmospheric CO_2 radiation in the 15 mm band of the infra-red. There is a correlation between CO_2 absorption and temperature of the source.

Reduced Weight

To obtain the selective levels in the atmosphere—there is an average separation between measurements of 5 km in vertical height—a simple vibrator working as a continuously oscillating spring takes the optical system in and out of the field. This neat device avoids the difficulties encountered with bearings and lubrication under the vacuum conditions of space. The weight of the instrument has been cut to 30 lb or so against the 90 lb or more, typical for previous flight designs.

The amount of data that has been flowing in since April with no indication of a breakdown, is overwhelming. By midsummer 30 million measurements had been registered or two pence a sounding in Dr Smith's computation. If the experiment continues to operate at full capacity say for a period of a year or so cost per sounding will be reduced to vanishing point!

The British Meteorological Office is also showing great interest in the Houghton-Smith Nimbus 4 radiometer material. It is processed daily at the Clarendon Laboratory, Oxford, into charts of temperature contours somewhat resembling the standard weather maps published in the newspapers and passed to the Meteorological Office's headquarters at Bracknell, Berkshire, at intervals of three days or so.

Plans are well advanced for adapting the technique to measure water vapour in the atmosphere from the successor to Nimbus 4, called Nimbus 5 and due for launch in 1972. This experiment will add 10 more channels to the 6 available in the current Nimbus 4 package. For 1973, a more advanced version again is under development for Nimbus F. This will return the emphasis to the atmosphere's temperature profile but extend measurements to heights above 45 km, a region so far scarcely probed. Measurements of water vapour and cloud are also expected to be included. ●

Nuclear and Space Research Round-Up

By Dr. K. A. Neelakantan

Composition of Lunar Rock

THE successful flight of Luna-16 towards the moon and back with a cargo of moon rock was a great technical feat. Still more remarkable and superb than this achievement was the landing of Luna-17 on the moon along with the moon bug Lunokhod-1. These feats have raised the perennial question as to whether man or machine is superior as far as space is concerned. While there is now no general consensus on this matter, some preliminary findings on the chemistry of the lunar soil brought back by the Luna-16 automatic probe have been disclosed by A. P. Vinogradov, Vice-President of the USSR Academy of Sciences at a press-conference in Moscow on October 12, 1970. This conference was organised jointly by the Academy of Sciences of the Soviet Union and the Soviet Ministry of Foreign Affairs.

The sample of the moon soil brought back by Luna-16 was taken in the Sea of Fertility at a point with co-ordinate 0° 41'S and 56° 18' E, this site was approximately 900 km east of the Apollo-11 landing site. The soil brought back was mostly regolite or the loose covering surface material of the moon. Regolite is a term proposed at the end of the last century for the loose surface material of a planet, irrespective of the conditions of its formation. It was reported at the conference that the drill with which Luna-16 was able to pierce the lunar soil struck against what was either solid bedrock or a separate large fragment of rock. Further progress of the drill did not exceed 5 mm which was confirmed by an inspection of the drilled core. The total weight of the specimen was a little more than 100 gm, and it represented a sample of the top 35 cm of the lunar surface.

Studies conducted at the laboratory on the ground have indicated that the soil on the whole is dark grey, almost black powder, which can easily be moulded and agglutinated into separate loose lumps. This feature distinguishes it considerably from the soil on the earth. The granularity of the moon soil increases with depth. The average size of the particles varied along the boring device from 70 microns on surface to 120 microns at the deepest point.

Studies are now being conducted on the mechanical, electro-magnetic and thermo-physical properties of the soil. The chemical composition of various fractions of the soil is also being investigated. Studies conducted so far indicate that the composition of the specimen may be divided into

(Continued on page 8)

World Nuclear, Space Research Round-Up

(Continued from page 7)

basalt-type rocks, felds par-type rocks, grains of various individual materials belonging to the basalt group, metallic iron particles and small vitreous spheres. Some 70 chemical elements, including a number of isotopes and short-lived radio-nuclides have been identified in the Luna-16 specimen.

According to Academician Vinogradov, inspite of the fact that Luna-16 samples were taken 900 km from the Sea of Tranquility, wherefrom the Apollo-11 took samples, the former differ from the latter in having a lower content of ferric oxide. At the same time, the overall composition of Luna-16 samples are closer to the Apollo-12 samples taken in the Ocean of Storms at a distance of 2,500 km from the Luna-16 landing site. The preliminary conclusion is that the rocks of the surface of the lunar seas are basaltic but differ somewhat in the content of their individual chemical elements; their composition approaches that of earth's primitive basalts.

Academician Vinogradov argues that the lunar seas were once flooded with volcanic lava, and the basaltic rocks were formed because they were the fraction most easily melted in the conditions which existed within the moon. He suggests that it may be assumed that the general course of differentiation of the substance of the earth and moon, and, probably, of other planets of terrestial type proceeded by similar routes, although they will have reached different stages of development.

World Uranium Reserves

THERE will be an acute shortage in the world's uranium supplies in another 5 years unless new reserves are discovered and exploited. This is the gloomy prediction in the latest report entitled "uranium resources: production and demand" of the European Nuclear Energy Agency and International Atomic Energy Agency.

Information collected from all countries having a nuclear power programme, with the exception of China, U.S.S.R. and the countries of Eastern Europe indicates that the nuclear generating capacity of the world will increase from 18,000 to 30,000 MW in the next 10 years. The present consumption of 15,000 short tons uranium oxide ore a year will increase to 38,000 short tons a year by 1974-76, and by 1980 the demand will be about 73,000 short tons. The report points out that if the consumption of uranium increases at the estimated rate, it will be necessary to discover and develop an additional one million short tons of uranium oxide by 1985.

There has been a recent boom in uranium prospecting and during the last couple of years, new deposits of uranium have been discovered in Canada, Australia, Central African Republic, Gabon, Niger and United States. At present, Canada and South Africa seem to have the most room for expansion of the existing industry.

In the opinion of the working party responsible for the report, it will be prudent to give greater emphasis now to relatively low cost prospecting with the objective of discovering new uranium deposits suitable for subsequent more detailed exploration. However, whether or not enough uranium will be found in time, the report seems reluctant to predict.

First Nuclear Power Station: Australia

BRITAIN and Canada are emerging as rivals to win the contract to build Australia's first nuclear power station to be located at Jerris Bay, 194 km. south of Sydney. The winner of the tender will be playing a major role in the development of nuclear energy in this region for many years ahead.

Initially, 4 countries have been told that their tenders are in the final stages of consideration. They are (1) Atomic Energy of Canada (heavy water, natural uranium fuelled reactors), (2) Nuclear power group of Great Britain (steam generating, heavy water reactors using slightly enriched uranium), (3) Krattwerke union of West Germany (pressurised water system using ordinary water and enriched uranium), and (4) Westinghouse Electric International of the United States (pressurised water system, using ordinary water and enriched uranium).

Australia, whose reserves of uranium have been boosted by the recent discoveries in its Northern Territory is insisting that the station must be able to use indigenous fuel. The Canadian system is the only tender which uses natural uranium so far. But, Britain is agreeable to grant Australia access to European gas centrifuge technology if she accepts her tender. This, however is subject to the conditions that Australia would have to undertake not to use the output of any enrichment plant or the technology provided to make nuclear weapons, and any centrifuge plant, would have to be subjected to the international atomic energy safeguards.

European Consortium for Space

A NEW European consortium, a seven-company grouping to collaborate on international satellite projects has been announced. The consortium will be represented by Marconi Space and Defence Systems of Britain, Etudes Techniques et Constructions Aero-spatiales (ETCA) from Belgium, Societe Nationale Industrielle Aero-spatiales (SNIAS) and Societe Anonyme de Telecommunications (SAT) from France, Masserschmitt Bolkow-Blohm (MBB) and Siemens from West Germany and Selenia from Italy.

The initial objective of the consortium is two major sectors of the European Space Research Organisation's proposed communications satellite programme. It has already begun work on a feasibility study which it hopes will be followed by an ESRO funded design contract and eventually a hardware contract.

The consortium has also its sights on the various air traffic navigation satellite plans both in Europe and the United States. This will be followed by competition for satellite projects being considered in Canada, Australia, India and other countries.

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 1, and printed by him at Conway Printers Pvt. Ltd., 167c, Dr. A. B. Road, Worli, Bombay 18.

Registered No. R. N. 9002/62

NUCLEAR INDIA

VOL. 9. Nos. 5 & 6 A PUBLICATION OF THE DEPT. OF ATOMIC ENERGY JANUARY-FEBRUARY 1971

Arvi Satellite Station Is Ready

ARVI, a village about 80 km. from Poona on the Nasik Road is now on the International Satellite Communication map of the world with the completion of the country's first commercial satellite communications earth station — a project executed by the Department of Atomic Energy. The Station — fully equipped to communicate via the Indian Ocean satellite Intelsat III with countries ranging from UK in the west, to Japan and Australia in the east — was handed over, ready for commercial operation, to the Overseas Communications Service on January 31.

The Station is equipped to communicate with at least eight earth stations in the Indian Ocean area, and can operate through 600 voice channels, as also through one television channel, with any of the eight stations in the area which is equipped with facilities for television transmission or reception. Each voice channel can be further sub-divided to accommodate 24 telegraphic channels. It is practically invulnerable to power and equipment failure due to the provision of a no-break power supply and automatically switched on stand-by equipment.

Reversal of Decision

Optimisation of indigenously manufactured equipment was an objective in this project. A part of the equipment had of course to be imported. To meet the import requirements the Canadian Government extended financial assistance of $ 4 million (Canadian). RCA Ltd. of Montreal, Canada was chosen as the principal supplier of imported equipment.

(Continued on page 11)



The 29.56 metre diameter antenna of the station silhouted against the Arvi sky.

IAEA Research Contract to BARC

A ONE-YEAR contract for research on the development of procedures for production and control of short-lived radiopharmaceuticals has been awarded to the Bhabha Atomic Research Centre, Trombay by the International Atomic Energy Agency (IAEA). The contract period commences January 1, 1971.

Short-lived radiopharmaceuticals like technicium-99m, indium-113m etc. and their labelled compounds would make possible some vital diagnostic procedures which can be used for locating brain tumours, for scanning vital organs such as the thyroid, kidney, liver, spleen and the lungs, and for placentography and blood pool delineation.

The very short shelf-life of these radiopharmaceuticals and the fact that many of them have to be prepared in the hospital just prior to use, necessitates the development of very fast and reliable quality control procedures for them.

The contract for developing these procedures was passed on to the Indian Ambassador in Vienna Shri V. C. Trivedi by Dr. Sigvard Eklund, Director General of IAEA on January 27.

(Continued on page 12)

Pollution of the atmosphere and aquatic sources is the pressing public health problem in many areas today. Indiscriminate release of wastes in air and water sources is recoiling adversely on human and other forms of li.e. Release of untreated waste into rivers, lakes, estuaries and coastal waters — the traditional recipients — is an important part of the problem. Aquatic pollution has reached alarming proportions in many areas resulting in the destruction of many forms of life, denial of fresh water streams to population and damaging public health.

The author discusses in this review some causes and effects, and new areas of aquatic pollution and recommends important measures which he feels must form a part of any legislation on prevention of water pollution in the country.

AQUATIC

Causes, Effects, Remedies

By P. R. Kamath, Health Physics Division, Bhabha Atomic Rese

THREE fourths of the earth's surface is covered with water. But only about 0.5% of this abundant supply is readily available for recycling as fresh water to man. About 97% is saline and the rest is congealed in glaciers and ice sheets, and a small percent is underground. The use and reuse of this limited supply is thus inescapable. The result is the inevitable degradation in quality of water, making it progressively unsuitable for drinking or use in agriculture and industries. Underground water supply in some areas may contain large mineral content, like fluorides, chlorides etc. and therefore not readily available as drinking water or for industry.

Quality Criteria

Water degrades when used, even if the use is only for the purpose of cooling. It gets polluted with waste heat and corrosion products. Chemical toxins and pathogens contained in industrial and domestic waste effluents cause damage to the user directly and also alter ecology in the region of discharge. Excessive release of wastes may result in fish kill, promote growth of algae, and breed mosquitoes. In areas of land release and shortage of fresh water, contaminated ponds may be used by cattle, or by villagers for washing clothes, utensils etc. and sometimes, even for cooking. The control on pollution is ideally exercised only when the quality criteria are enforced at the point of release of effluents whether from a municipal treatment plant or an industrial outlet. The economic aspect of treatment would depend on the end-use of the effluent. If the effluent is being recycled in a chemical industry, the treatment would be adequate if it removes only unwanted impurities. If sewage effluent is used only for irrigation in a controlled manner, the treatment need not be expensive.

The restrictions on discharge of untreated effluents have led to the representation of pollution prevention as anti-technology. If the problems of waste release are taken care of at the design and planning stage by the right choice of site, process and outfall, the wastes can not only be released safely, but perhaps useful by-products can be recovered from them.

For historic reasons effluent releases from nuclear industry have received serious public attention. Controlled releases have been made after due consideration of all the parameters and followed by monitoring of the receiving environment. Describing the practices in the nuclear industry, where discharge criteria are extremely stringent, Shri H. N. Sethna, Director, Bhabha Atomic Research Centre said at a seminar on Pollution and Human Environment in Trombay last year:

"The approach to environmental control of pollution in the nuclear industry is based on the principle of containment of contaminants at source, and controlled release to the environment when inescapable. We set limits on releases based on the safe receiving capacity of the environment and the control is achieved by effective methods of treatment, decontamination and containment of the pollutant". "This is perhaps the only industry" he said, "which looks into the environmental pollution control and demonstration of conformance to set norms as a part of operational responsibilities."

Scientific planning of pollution control at a nuclear site consists of: preoperational study of dilution and dispersion mechanisms, radiation background, demography and ecological uptakes, followed by regular monitoring of the environment after the operations commence.

Cost Prohibitive

A new industry can look at the pollution problem with enlightenment and plan the site development, housing, drainage etc. with great care. Long established industries with residential colonies closing in on site boundary may find it difficult to conform to the safety standards.

Pollution abatement can be also cost-prohibitive and management may face a closedown unless it receives financial assistance to set up treatment plants or modify processes. Distille-

"The nuclear industry is perhaps the only one which looks into environmental pollution control and demonstration of conformance to set norms as part of operational responsibilities."

ries, tanneries, paper and textile industries in this country may not stand scrutiny of the standards of effluents discharged or of the public waters on receiving these effluents.

As new industries producing rayons, petrochemicals, synthetic drugs, fertilisers and petroleum are rolling on to increased production it is time to introduce rigorous vigilance and enforce sanitary control on discharge practi-

POLLUTION

tre, Bombay

ces. Domestic wastes and raw sewage are presently discharged to surface streams; and municipal sewers are used for disposal of waste indiscriminately (hospital, laboratory, detergents, workshop oils) with total disregard to problems of treatment and disposal.

It is probably not popularly known that the trace impurities present in the waste effluents get accumulated in the environment and reach man through dietary intakes in a concentrated or modified manner ultimately to end up as a 'killer'. One of the pollutants which is receiving serious attention of sanitary and health experts in Japan, Scandinavia and USA is mercury (Hg). The toxicity of mercuric compounds is pretty well-known but what was not known was that highly toxic organic compounds of mercury are produced in the environment from inorganic salts of mercury present in the waste effluents. In 1953, many Japanese villagers living near Minimata Bay showed neurological disorders. Some of them died while many others suffered disabilities permanently. Minimata village had a fertilizer plant for many years. In 1949, it started manufacture of vinyl chloride (a base material for production of plastics) using mercury catalyst. The production of vinyl chloride, which was only 60 tons in 1949, went upto 18,000 tons in 1959. It was suspected that the villagers suffered because of eating fish and oysters from the Bay which had accumulated mercury from plant effluents.

In 1961-62 the Minimata disease struck again in Japan consequent to waste water releases from acetaldehyde manufacture. Forty-one fishermen suffered as a result. It was estimated that about 500-2000 g/day of methyl mercury was produced in a side reaction and was being discharged into the waste stream. It was discovered in a survey that many industries were releasing methyl mercury from catalytic processes. Oysters containing methyl mercury were fed to cats which immediately displayed neurological disorders. Studies showed that whatever be the form of mercury discharged into waters, mercury present in sea food was always an organic compound of mercury-ethylmethyl, dimethyl or methoxy ethyl mercury, produced through microbial action. It was possible that the disease took an epidemic form in Japan because of the dietary habits of eating raw fish. Examination of the post-mortem tissue of some victims indicated in one study that the neurological disorders appeared at a Hg concentration of 20 μ g/g brain tissue, and ended in fatality at 30 μ g/g. Hair from a Minimata victim showed 500 μ Hg/g. The drinking water standard for Hg in Japan is nil for organic mercurial compounds. In Sweden, the limit is fixed at 1 ppm in harvested fish because of a natural background of 0.1 ppm in waters. Organic compounds of mercury were used in Sweden as seed-preservatives and for preserving paper slimes. Alkyl mercury was banned for these uses in 1966-67. Inorganic wastes arising from industrial processes containing mercury and other heavy metal salts, sulphates, fluorides, pickling wastes, radionuclides, arsenic and other toxins from mining, detergents like benzene sulphonates are non-degradable and on discharge, they persist in the environment. Even when discharged at low levels, say one-tenth of the permissible levels of drinking water, the contaminations may get into the food chain concentrated by factors of thousands in fish tissue.

Pesticide Kills

The Sunday Times, London of October 25, 1970, reported an incident where a pregnant woman driving through Swedish woods was exposed to a spray of 2,4,5-T from a tank-car. This compound is reported to have been used in Vietnam as a jungle defolient. She gave birth to a child. seven months later, with severe physical deformities. It was later revealed that 2,4,5-T was teratogenic (birth defects producing) and abnormalities comparable to thalidomide proportions have been reported from Vietnam. Among the Lapps, reindeer foetal kills have been reported from the forests after grazing on plants previously subjected to heavy sprays of 2,4,5-T and 2,4-D. The tissue analysis showed that the dead animals were exposed to such compounds. These and other compounds have been often used in the preparation of pesticides, herbicides, seed preservatives etc. and find way into

(Continued on next page)

"If the problems of waste release are taken care of at the design and planning stage by right choice of site, process, and outfall, wastes can not only be released safely but perhap utilized to recover many byproducts."

"Water degrades when used, even if the use is only for the purpose of cooling. It gets polluted with waste heat and corrosion products."

public streams along with fertilizer salts.

Organochlorine pesticides used in India namely DDT, aldrin and dieldrins, lindane etc. are characterised by persistence in the environment. Over the years some immunity has been developed by the organisms against these compounds. This has resulted in the application of more powerful biocides. Organophosphorus compounds like parathion, malathion and phenoxy acetate compounds mentioned earlier and carbamates have come in use. The organo-phosphorus compounds inhibit the production of cholinesterase, an enzyme required to neutralize build-up of acetylcholine in the body.

The hazards from pesticides could be imagined from the fact that about 32,000 tonnes were imported in this country in 1968-69. To this should be added unaccounted quantities of conventional preservatives, copper compounds, arsenicals and other toxic chemicals added to imported grain and seeds and sprays of DDT in the storage of grain in godowns. However, from observations reported it would appear that acute hazards have resulted only from direct ingestion of contaminated food and drinking water supplies.

Oil Spillage

Organic wastes are mostly degradable although there is considerable time lag before total decomposition. Oil spills and sewage discharges are of great importance in this category of wastes.

Accidents to tankers resulting in oil discharges to the sea have received considerable attention after the "Torrey Canyon" accident (1967) when 110,000 tons of tanked oil were spilt into the sea. A more recent spill (1970) in the same region was when "Pacific Glory" carrying 77,600 tons of Nigerian crude collided with another tanker. Oil spills in open seas and coastal waters have been many, through transport and from unloading operations. Microbial degradation of the oil was too slow to prevent the damage: trapping of birds, movement of oil to other areas, fish kill, contamination of beaches etc. The direct toxicity of crude oil to fish is low, but damage is caused to the gills. Oil spill also interferes with the photosynthetic processes, and causes destruction of sea fauna. Thousands of gallons of detergents were discharged into the oil spill for dispersion during the "Torrey Canyon" accident which later proved that detergent was more toxic to fish than oil itself. Nearly 50,000 tons of oil were set on fire, using 160,000 lbs of TNT, 10,000 gallons of aviation fuel and 3,000 gallons of napalm. The sea coast became sterile for fish for some years. In another instance of a 600 ton spill in the USA, the oil got into oysters and scallops and virtually annihilated coastal fishing.

Tankers discharge wash liquids in the coastal waters, a practice not permitted in most countries. In the Scandinavian countries, such spills are about 350 per year and in Japan about 300. Oil bearing wash waters discharged into the sea in Japan were reported to be 10 million tons in 1964.

These instances of pollution through accidents in transport of oil and toxic materials over high seas and waterways call for considerable research for prevention of pollution. Several oil companies have produced degradable detergents, non-toxic to fish and better engineered containment. Engineering devices have been introduced to avoid collisions and improve manoeuvrability. Another approach adopted for cleaning up is to generate chemical blooms around the spill to contain the patch and then use absorbents or suction to remove oil layers.

Other causes of oil pollution are due to shore borings and blow-outs, oil exploration in submarine areas and incipient discharges from refineries and petrochemical industries. The last mentioned types contain tars, benzpyrines, and other carcinogenic constituents. These have been found to get biologically magnified through the plankton-nekton chain and reach man. The discharges from the dye industry — like aniline colours, and nitro compounds from explosives, come under similar toxicity level.

It is generally believed that the sea is so big that it can be used liberally for dumping of wastes. Apart from biological magnification already described, the coastal discharges are likely to return to land leaving floating faecal matter on beaches and toxic contamination in sea foods. Oysters, crabs, lobsters may accumulate these toxins to a remarkable extent. Other adverse features for dilution are tidal-

"Despite our very enlightened interest in community health, most towns and cities in India still consider sewage treatment as wasteful expenditure..."

ly influenced oscillating flow of waters in the region of discharge. For efficient sea disposals, submarine pipes have to be laid and discharges made at some safe distances without damage to deep sea fishing. Marine disposals call for intensive scientific investigations on water movement, sediment interaction and transport, biological magnification, effects on ecology and recreational use of shoreline.

Of the degradable wastes, the largest in volume are domestic sewage. The production of domestic wastes is comparable to volumes of water used in a conurbation. Therefore in the development of residential colonies, sewage treatment and disposal practices, drainage system has to be carefully balanced with the quantum of drinking water supplies. In many places the water supply may be very well-developed but there may be an utter neglect of the treatment and dis-

OLLUTION

posal facilities. **Inspite of our very enlightened interest in community health, most towns and cities in India still consider sewage treatment as a wasteful expenditure and discharge raw sewage through open drains into rivers, seas and public streams and on waste land. Vegetables and farm produce are grown using sewage fertiliser carrying bacterial and parasitic infection.**

The damage from discharge of raw sewage to public streams does not come from pathogens alone. The discharge may alter the ecology of the area. If the discharge is such that it has a high biochemical oxygen demand, the stream gets depleted in oxygen and fish die or migrate. If the discharges

"It is not that the technological solutions and standards are not known for water quality management. Public opinion in the country is not strong enough to force municipal establishments to provide clean drinking water."

contain a lot of nutrient salts, particularly phosphates and nitrates, there is plenty of algal growth which cuts out light and depletes oxygen in lower layers. This is briefly the process of eutrophication by which a stream is totally destroyed.

Some algae are poisonous and malodorous. In Storm Lake, Iowa, U.S.A., 8,000 domestic and wild birds are reported to have died by eating algae. Where heavy faecal discharges are made and temperatures rise because of bio-degradation, blue-green algae flourish. In Africa, the water hyacinth grows plentifully due to the presence of high nutrients in domestic discharge, and snails feed on these. Flukes or worms feed on snails and enter the body through water. Bilharziasis, a serious disease affecting liver and intestines is caused by flukes. Some infections have been observed on the west coast of Maharashtra but the high frequencies are likely from use of reservoir waters. The "Hindu" (Dec. 24, 1970) gave an account of the Guinea worm infection in Gulbarga, Mysore from using waters from stepwells and describing suffering of rural folks for over 22 years. Water-borne infection is probably uncontrolled wherever the surface waters are directly used. It is probably not realised that rain water can itself be a source of infection transporting atmospheric, land and roof wash into open streams and ground water. In some countries proper channeling of rain water has been insisted upon.

Ooty Lake

A lake can be destroyed entirely in the process of eutrophication. It is reported that Lake Eerie in the U.S.A. is totally lost through eutrophication. In a recent paper by Miakhan and Raman at the Seminar on Pollution and Human Environment in Trombay, attention was drawn to the Ooty Lake in the Nilgiris which is in a state of heavy eutrophication. The only way to save the lake is to develop sewerage in the Nilgiris and have a good treatment plant. Among discharges of nutrient pollutants to public streams from sewage and agricultural activities are nitrates that reach ground water and appear in drinking water. High nitrate concentrations cause methemoglobinemia or the 'blue baby', and cause death of poultry.

If treatment methods cannot be immediately employed, the discharge of raw sewage should be adequately planned. The discharge point should be well located so that the downstream user's supplies of drinking water are not contaminated, solids do not land on beaches and dilution and oxygenation ensures conformity of public waters to ecological requirements. Planning of outfalls is unfortunately poorly attended to with the result that irreparable damage results. It is too early to forget the unfortunate epidemic in Delhi in 1955, where 35,000 people suffered and a large number succumbed to infectious

"Water management in most parts of the country is in a sorry state. The quality of public water supply is not well assessed because the machinery for country-wide inspection of water quality is inadequate."

hepatitis by drinking the polluted water of the Yamuna.

It is not that the technological solutions and standards are not known for adopting treatment practices for water quality management. Public opinion in the country is not strong enough to enforce municipal establishments to provide clean drinking water.

A few years ago a proposal to link the national rivers into a national water grid was made in this country. Recently the need for setting up a national waterway was again highlighted and engineers were called on to prepare a blue-print for this gigantic venture. A national project of this magnitude should have a serious scientific pre-evaluation of potential public health hazards in regions through which the waterway flows. It is not only necessary to take stock of existing water quality management practices but assess future waste arisings. Our experiences of regional harvesting of rivers, depletion of soil minerals through seepage, siltation in our national reservoirs, the hazards of flooding, movement of water-borne contamination from region to region, transport of toxic materials and discharge of sewage and industrial effluents should be reviewed, lest the interstate waterway introduce a new vector of interstate wrangling and recrimination. National grids of this kind are very good in conception — the idea appeals to the public imagination, and sense of national integration. But before the ideas are given a foothold in the public mind it is in public interest to draw on experiences of water quality management in international river regimes like the Rhine and Danube in Europe.

(Continued on page 12)

Remote Sen

By Dr. VIKRAM A. SARABHAI, Chairman, Atomic Energy Cor

SPACE exploration has advanced along two major directions. The first is concerned with the outward exploration, which encompasses the efforts to reach out into the space, to investigate the physical nature of the solar system, of the interplanetary space, etc. The other is concerned with the exploration inward. This aspect of exploration is concerned with looking back towards the earth from space — the inverse of Astronomy. Remote Sensing belongs to this kind. In its broader definition, Remote Sensing represents the joint efforts of using modern sensors, data processing equipment, information theory, processing methodology, communication theory and devices, space and airborne vehicles, and large systems theory and practices, *in coordination with the relevant earth sciences disciplines* for the purpose of carrying out aerial or space surveys of the resources on the earth's surface or just below it. It is concerned with the direct application of everything connected with space technology for the betterment of man, particularly in the developing nations. Hence it is of great relevance to India.

Oceanography

MORE than seventy per cent of the earth is covered by the oceans. Hence any earth resource survey should include oceanic surveys. Unlike the static ground surface, the ocean surfaces are dynamic, subject to continuous change. Their expanse coupled with their dynamic nature, make a broad scale surveillance by conventional methods of ship-borne instrumentation practically impossible.

All the fresh water used by man in agriculture and industry is being recycled into fresh water through evaporation. The role played by the location of abnormally warm oceanic areas in causing the vagaries of the rainfall (including that of the Indian Monsoon) is gradually being realised by meteorologists. Thus, a survey of the oceans becomes essential for the forecasting of weather over land and sea. On behalf of the World Meteorological Organisation and the International Council of Scientific Unions, a group of meteorologists are now involved in a project known as Global Atmospheric Research Programme (GARP). They have realised that the Tropical Oceans play a large part in the generation of global weather systems. In order to investigate the details of this role, plans are afoot for conducting an experiment in the northern equatorial Atlantic in 1973. The planners have definitely stated that a geosynchronous and a couple of sun-synchronous satellites for surveying the oceanic area under investigation are essential requirements for the experiment.

For over a decade (since April 1960) weather satellites have been taking pictures of the cloud cover over the globe. Initially pictures were taken during sunlit hours only. Using infra-red sensors, pictures are taken now-a-days during night-time also. Besides cloud pictures, sensors in different infra-red channels provide information on the temperatures of the surface observed by them — cloud tops, or ocean surface or land surface over clear areas. Very recently interferometer equipment installed in satellites monitoring the 15 mm band of carbon chloride and the 6 mm. band of water-vapour are providing information on the vertical distribution of the temperature and water-vapour in the atmosphere from surface to an altitude of 50 km. This satellite technique appears to be the only feasible method for obtaining the temperature and humidity structure over the oceans.

The Gemini Manned Spacecraft Missions brought several colour photographs of the earth's surface taken during the flights. A vertical view of some coastal areas in Florida, showed shoal areas and underwater detail through colour tones. Sedimentation patterns over large lakes were clearly discernible. Several atolls 60 miles or less in diameter appeared in the central Pacific. Such ocean photographs have already been used to revise hydrographic charts.

Biological productivity of plankton and fish is perhaps the most important oceanic resources. In the years ahead this resource must be surveyed, monitored, conserved and wisely harvested. There is a significant correlation between ocean temperature and the location of large schools of fish so that information on the ocean temperature through infrared sensing would prove valuable to the fishing industry. Surface temperature measurements also help to identify locations of highest plankton concentration and therefore possibly locations of high population of fish.

The oceans absorb surplus carbon-dioxide in the atmosphere via phytoplankton which converts it into oxygen. Some scientists feel that the overload of industrially emitted carbon-dioxide might have already saturated the oceans capacity to effect this conversion. This also makes it necessary to monitor the areas of phytoplankton. Phytoplankton can be killed or their vigour impaired through oil slicks or pollution films. With so many oil tankers, the risk of such films is large over the Arabian Sea. With many countries going in for under-

* Presidential Address delivered at 8th Annual Meeting of the Indian Geophysical Union on Dec. 29, 1970.

ng Benefits to India*

water drilling operations for oil, the risk of oil slicks spreading over oceans is on the increase. It is desirable to monitor them. A satellite sensor scanning in the near ultra-violet can detect oil slicks.

It is not known definitely whether schools of fish create thin films of fish oil. If so, the same technique of ultraviolet sensing will detect schools of fish swimming just below the surface.

Subtle gradations in ocean colour shown in the Gemini photographs correlated well with ocean flora. Hence this technique can be used to indicate areas of high food content where fish are more likely to be found. As already mentioned ocean colour gradation in shallow waters can be used to up-date hydrographic charts. This is very necessary as the action of tides and currents are continuously changing the contours of the sea bottom faster than the classical hydrographic surveys. From a space platform, small difference in colour can be detected through the use of multispectral photography or scanning imagery, using narrow band filters.

The areas and intensities of the sunglint provide data on the surface waves, which can be related to the surface wind. The state of the sea also produces differences in the sea colour when viewed vertically. Remote Sensing techniques for these features installed in spacecraft can provide information on the state of the sea. The state of the sea can be inferred more definitely using microwave radiations. However, the installation of such sensors in satellites is not contemplated in the near future. The information about the state of the sea can be used for appropriate re-routing of ships along routes offering less resistence to the ship's motion.

The space oceanographers say that they will now strive for data on the following: The surface wind field; wave system; ocean currents — their boundaries and speeds; eddies and divergences; areas of upwelling; depth of the mixed layer; water temperatures and their gradients; biological productivity; fluxes of heat, moisture and carbon-dioxide.

Geology and Mineral Resources

IT is well known that the primary non-human inputs into a nation's economy are the mineral resources, and the economic growth of a nation depends upon the discovery and the effective use of those resources. The geological surveys of the various nations have been entrusted with the job of discovering and mapping these mineral resources. In the past, the field geologist studied and mastered a small area which he projected into a broad, regional picture to which others contributed. Large-scale geologic maps were the laborious product of years of surface exploration. Now, in addition to aerial photography, geologists will have available the big, synoptic view offered by remote sensing. These systematic space pictures will offer geologists a broad, integrating panorama from which they can select observables of interest for close-up looks by aircraft or ground parties.

Known relationships exist between concentrations of mineral and fuel resources and particular geologic features. Petroleum and metallic mineral deposits, for example, are frequently found near structural features such as folds or faults. In a space photograph, part of an entire mountain range could consist of a series of folded rocks, and in the series of folds might lie an anticline or dome which could yield oil. Aerial photographs have been used to identify such features, but pictures from orbital altitudes have proven to be superior for viewing the larger linear geologic features. A new fault system even in Southern California was first discovered in space photographs. Geologic fractures and faults are even more obvious in radar images than in visual pictures. Radar also penetrates clouds and haze, and can be used during night time. Although radars will not be carried aboard ERTS A and B, they are planned for later flights.

Satellite observations may be useful to geologists in other ways. Some mineral deposits yield heat through oxidation and may be detected by infrared sensors. Repetitive satellite observations of the melting patterns of snow may also point to such deposits. Infrared imaging also indicates temperature differences at or near the earth's surface. These differences may indicate possible sources of geothermal power and volcanic activity. Repetitive observations in the visible and infra-red regions may disclose crustal movements and thermal gradients which could provide timely data for predicting natural disasters such as earthquakes, volcanic eruptions, and landslides.

An example of the manner in which a developing country has made use of this technique is provided by Brazil which has an active remote sensing programme in cooperation with NASA. In the first phase they trained 14 scientists and engineers in U.S.A. In the second phase, using these trained personnel 40 Brazilians were trained. In the third phase airplane flights were conducted over known areas of

Brazil, using instrumented aircraft loaned by NASA. The data were analysed jointly.

Their initial test site for geology was chosen to be a well-known area — the "Quadrilatero Ferrifero". This area had been surveyed for 16 years with conventional methods. By using the sensors on aircraft they were able to produce a geological map which matched the existing one made with so many years of work. By using signatures calibrated with known features of the site, they have been able to double the surveyed area of the "Quadrilatero Ferrifero". In this additional area they have signatures indicating a huge deposit of itabirits (a quartzite containing micaceous hematite). This discovery is presently being verified. Another result was obtained from almost constant warm-spots indicated in infra-red photography. These spots corresponded to "Canga" (iron ore) deposits. Apparently, since the thermal conductivity of the "Canga" is higher than its surroundings, the internal heat of the lithosphere is conducted to the surface by the mentioned deposits showing up very clearly in the infra-red photos.

Hydrology

FRESH water is an extremely important terrestrial resource which requires proper management. The basic principle in water management and utilisation is to intercept the water when it is still fresh and to utilise it for human benefit, before it returns to the atmosphere as water vapour or to the ocean as contaminated water. The atmosphere contains about ten millionths of the total water, and all fresh water returns to the earth after staying in the atmosphere for a brief period, on the average, 12 days. In other words, the atmospheric water vapour is replaced about thirty times a year. However, its passage to and its precipitation on the land are extremely variable in amount and distribution.

Hydrological data are collected through raingauge stations, snow-gauge stations, stream-gauging stations, snow-depth stations, water quality stations and ground water observation wells, evaporimeter stations, etc. Such a collection of data demands considerable time, funds and technical skill. Hydrology is a natural science very highly dependent on current data; old data are of value only for probability studies.

Water management activities include the mapping of water, studying its properties, predicting its behaviour, impounding it, diverting it, and using it to serve industrial and agricultural needs and to create electric energy.

Thus perishable hydrological data are to be collected expeditiously over a wide area if the performance of water management functions are to be satisfactory. Space technology using remote sensing and communication satellites appear to provide a satisfactory solution for the data collection problem. They can provide large scale, repetitive imagery of water systems significantly supplementing data taken at individual points. In addition, automatic sensors collecting data at individual points can transmit the measurement to a satellite, which can rapidly dump the data to a hydrological centre. Such an operational system has a feasibility of providing global, synoptic, repetitive real time coverage of the major aspects of the Hydrological Cycle.

A few examples of what can be done with such system are the following:

The available water in an entire river basin or lake system can be monitored repetitively. Repeated observations in the visual, infra-red, and microwave regions of the spectrum can be made of snow, glaciers, ice accumulations and melting patterns. These changes can be monitored during the seasons of the year over areas too large to survey by conventional means. More accurate predictions of the run-off can be made. These forecasts, in turn, will enable hydrologists to issue better flood warnings and to regulate efficiently the impounding and release of water in reservoirs. Management of programmes of flood control, irrigation and power production, as well as water for urban and industrial consumption can be wisely done.

In addition to reporting water inventories, remote sensing may help to reduce water losses. Underground fresh water is being lost to the sea. Aerial infra-red detectors flown over the coast of Hawaii showed nearly 250 underground springs discharging cool fresh ground water into the comparatively warm ocean. Such pictures may guide water prospectors to most likely drilling points. The same thermal principle can be used to locate areas where cool underground brackish water intrudes into the warmer rivers. The location of such zones can help in the protection of municipal water supplies taking off from the rivers.

Other water losses are caused by evaporation and the transpiration of water wasting weeds. These weeds have long tap roots, and the evapotranspiration by such weeds tend to lower the water table. Aircraft and satellites can locate and map areas infested with such weeds.

All these can lead to significant economic benefits to any nation availing itself of the appropriate space techniques.

Geography and Cartography

ANY plan for national development requires current accurate maps. Geographers are concerned with the location, arrangement and association of the earth features like rivers, mountain ranges, sea

enefits

coasts, and of man-made features like roads, townships, artificial lakes, etc. Maps form the framework on which these features are marked. Maps also define the location of the various mineral resources. Normally such maps are prepared through ground triangulation surveys involving considerable time and effort and therefore funds also. Cartographers are continuously on the game of re-survey and preparing maps, and yet 70% of all the small-scale maps of the world are out-of-date and the remainder inadequate.

The best current method of obtaining accurate small scale maps of large areas appears to be aerial photography—an example of classical remote sensing. The compilation of small scale maps is a slow laborious process, even when aerial photography is employed. At least half-a-million such photographs would be required to make a satisfactory photo-mosaic of a country of the size of India. Preparing such a mosaic will be time-consuming and costly. From a satellite altitude, such a panorama of India would hardly require 200 pictures, which could be assembled in a few weeks time. In just one pass, the Gemini Astronauts photographed almost 80 per cent of Peru in a total time of only three minutes. In the mosaic thus obtained, one could see the gross patterns of land use, distribution of snow, the levels of the lake, geological forms of significance — in fact this contained more information than any available map of the region.

Since the sunlight angle changes during an aircraft flight, aerial photomosaics display variations in shadow patterns and texture, complicating their interpretation. Placed in an appropriate sun-synchronous orbit, a satellite is capable of producing pictures of the earth under virtually constant lighting conditions. In a sun-synchronous orbit, the satellite crosses the equator or any parallel of latitude at the same time at each pass. Since the orbit plane of the satellite always maintains the same fixed angle with respect to rays of sunlight, the illumination of ground features is consistent. Shadows in each adjacent satellite's swath always point in the same direction. Images of large areas composed of pictures taken during many passes will display the same constant illumination. Satellite pictures are also geometrically superior to aircraft photographs of large areas because of the straight down view. The distortions caused by oblique camera angles are eliminated. These features make possible automatic processing and interpretation techniques that are difficult or impossible to utilize working with aerial observations.

New maps made by satellite and supplementing existing specialised maps will be of great value to all of the geographical disciplines. Demographers will have new, updated imagery to use in assessing changing patterns of population and migration. Land use planners can see the actual patterns of land use all across the country. They can also see seasonal changes in these patterns. Urban geographers and city planners will have a continuous record of changing urban patterns. Regional planners, transportation planners, and cultural geographers will also strengthen their analyses with this new information.

Agriculture

IN any country, especially in a developing one, agriculture constitutes a large fraction of the gross-national product. In India it is almost 50%. Therefore, national benefits from an application of operational remote sensing techniques to agriculture can be large and appealing.

Repetitive aerial surveys during the vegetative growth and harvest times of a crop can provide reliable inventories of the size of the harvest. These techniques have been used for grape crops. Remote sensing from orbiting satellites promises to extend such predictive techniques to very large areas and many crops like rice, wheat, maize etc. When photographs are taken in colour, tone and texture differences are revealed, which can be used for identifying and distinguishing various species of plant life.

Use of multispectral (including infra-red) imagery is expected to be of great help in the identification of crops and timber species, in the analysis of crop vigour, in the early detection of crop disease and other forms of crop stress due to deficient water supply. Diseased or stressed plants reflect or emit electromagnetic radiations in the visible and infrared differently from healthy and vigorous plants. Large scale results of extensive irrigation practices and fertilisers can be more easily carried out through remote sensing than through spot checks carried out from the ground. Rapid inventories of livestock can be made with remote infra-red sensors. The utility of repetitive observations of large agricultural areas over short period of the order of one month cannot be overemphasised. Remote sensing is perhaps the only technique capable of achieving this with any degree of reliability.

Existing Experiments

INDIA has successfully carried out a small remote sensing project on the early detection of the coconut blight disease.

It is well known that the Wilt (root) disease is the most important disease of coconut in the Travancore-Cochin area of Kerala. It affects about a lakh of acres of plantation and is estimated to cause an annual loss of about 10 million rupees. Hence any method of detecting the disease early is of great economic value to Kerala. Remote sensing from aircraft appears to be a method for early detection of

(Continued on page 10)

Space Technology Fallout for Developing Nations

coconut wilt.

After hearing a lecture on "Remote Sensing", the Director, Indian Agricultural Research Institute, New Delhi, evinced an interest in the problem of detecting coconut wilt through Remote Sensing. ISRO* communicated this interest to NASA, which arranged for a preliminary examination of the problem by agricultural specialists at the University of California at the Davies Campus and the Berkeley Campus who felt that it should be possible to locate the diseased trees through "Remote Sensing", at an early phase of the disease.

On ISRO's request, NASA arranged to send a scientist in February-March 1970, to help us take the necessary photographs. He brought with him a 70 mm Hasselblad camera, another 70 mm camera and the necessary films.

Coconut plantations over a few areas in Kerala were taken. ISRO's helicopter at Thumba was made use of. The photographs were taken from heights of about 300 m. using Kodak Aerofilms and also black-and-white films using different colour filters. A total of four hundred 70 mm pictures (coloured and black-and-white) were taken over a period of five days. Most of the photographs showed fine detail.

The directors and staff of the coconut research stations in South India extended their cooperation. Areas containing infected and healthy trees were marked out by flag so that the aircraft could recognise the areas to be photographed. A scientist from the Atomic Minerals Division of the Department of Atomic Energy, experienced in aerial photography, was also present during survey flights.

Scientists of the Indian Agricultural Research Institute (IARI) were entrusted with the task of analysing the photographs. The case histories of the tree clusters in the Kayangulam Coconut Research Institute in relation to the Wilt (root) disease are available at Kayamgulam. The scientists there have done considerable work on the causes, symptoms and effects of this disease.

A scientific report is under preparation by the IARI.

A first analysis of the pictures have shown :

a) That the crowns of healthy coconut trees appear red in the infra-red false colour films
b) That the Jack trees appear red, but brighter than healthy coconut crowns in the same film
c) That the cashew trees appear pink in the same film
d) That some trees apparently looking healthy, but which have recorded a weaker infra-red reflectance on the film, were found to be infected by the virus. This was revealed by the presence of the virus in the juice of the leaves on examination by an electron microscope.

The last result confirmed our anticipation that the disease could be detected by the new technique even before visual symptoms appeared.

Implementing an Earth Resources Remote Sensing Programme

IT is suggested that developing nations which do not have plans of using space technology for the survey of their natural resources may seriously consider the advantages of evolving such national plans. The development of the skills and expertise necessary for earth resources surveys through remote sensing techniques can be accomplished through a phased programme. During the first phase, about a dozen scientific and technical personnel can be trained at universities and scientific departments of a country like USA., where these techniques are fairly well developed. If scientifically mature persons are selected, this training period need be only about a year. If necessary, the United Nations Development Fund should provide financial assistance for the travel and living expenses and the cost of training.

In the second phase these trained personnel returning to their home country will train about forty or fifty scientists and technicians within the country. During this phase, it will be necessary to have laboratory and field equipment including instrumented aircraft. Remote sensing techniques reveal details of surface topography and of other features. Consequently, there can be considerable hesitancy on the part of a developing nation to collaborate with a foreign nation in carrying out earth resource surveys particularly when economic factors and lack of specialised hardware and technical know-how compel the use of foreign aircraft and crew. This difficulty can be overcome if an international agency carries out the training and initial operational surveys on behalf of such nations, with nationals in full charge of the acquisition and analysis of data.

For implementing programmes of this type, each country should have a national coordinating agency set up at the very beginning of the programme. This agency should appoint a full time manager for the purpose and either appoint about forty scientific personnel for a period of two years or second them from other departments for the same period for full time work.

The Indian Space Research Organisation (ISRO) has already taken steps to have an infra-red (12 mm) scanner constructed in France in Prof. Morel's laboratory. An In-

(Continued on page 12)

* Indian Space Research Organisation

Arvi Satellite Station

(Continued from page 1)

Originally, it had been decided to entrust the job to a foreign company on a turn-key basis. This decision was however reversed in April 1968 in favour of the Department of Atomic Energy which had already acquired adequate expertise in the area: by then it had set up the Experimental Satellite Communications Earth Station at Ahmedabad in August 1967 where it was training personnel from India and other developing countries in satellite communications technology.

Risk Involved

The Department of Atomic Energy thus assumed a unique responsibility: that of a prime contractor. Besides fabrication and erection of the antenna and the drive and servo systems, the effort involved a broad spectrum of tasks including project management, total systems engineering, civil engineering (including design of the antenna foundation), power supply and distribution systems at Arvi and the rearward communications links with Bombay. In accepting the project, it could be said that a degree of risk was involved as failure to meet the rigid standards of performance set by INTELSAT would have disqualified the station from the international communications system. Performance tests have however borne out the high level of skill and expertise invested in the project: the station in some ways exceeds the requirements of INTELSAT.

The Station is equipped with a giant 29.56 m diameter fully steerable antenna (already a familiar landmark on the Poona-Nasik Road) which automatically tracks and locks onto the Indian Ocean synchronous satellite 35,900 km above the Equator. Manufactured entirely in India and erected by Indian engineers, this antenna is considered in some quarters to be "the best made, and performing unit of this type". The design of the antenna was evolved by Blaw-Knox of U.S.A. and supplied through RCA, Canada. A considerable amount of Indian effort was involved in the antenna's manufacture and erection. This included adaptation of the specification of materials according to their availability in India, adaptation of drawings to Indian engineering practice and manufacturing equipment, as also modification of erection procedures to suit available Indian equipment.

Calculations required to achieve the "best fit surface" were not part of the information supplied by Blaw-Knox and had to be undertaken by Indian engineers.

Exceeds INTELSAT Requirements

The antenna plays a significant role in the performance of the Station. Reception conditions in satellite communications being critical owing to low intensity of signals, the strength of the signal has to be increased to make it relatively greater than the interference generated in the receiving system. This is achieved by sharp focussing of the signal by the peculiar geometrical shape of the antenna (paraboloid of revolution). The accuracy of the manufacture of the panels constituting the parabolic antenna and the precision of their alignment required complicated mathematical work on a high speed digital computer. The success achieved in this effort by Indian engineers is responsible for the Station exceeding minimum INTELSAT requirements for net-work stations.

DAE constituted a project, called the ARVI Satellite Communication Project—ASCOM Project — for this purpose under the leadership of Wg. Cdr. K. R. Rao, Director of ESCES, Ahmedabad. The ESCES, Ahmedabad provided system engineering support. The design of the drive system and the sophisticated servo system of the antenna was evolved locally and manufactured by the Electronics Prototype Engineering Laboratory at the Bhabha Atomic Research Centre. This equipment is the first of its kind designed and built in India. The principal responsibility for the construction of the antenna was entrusted to Shri N. K. Ghosh, Consultant from TELCO lent to this project.

Saving in Foreign Exchange

In the Indian effort in the project as a whole (including the rearward communication system), besides the Department of Atomic Energy, many other agencies also played a significant part. For example, the message control console (through which communication between earth stations on operation matters is established) was built by the Overseas Communications Service; a major part of the multiplex equipment at Arvi as well as at the Videsh Sanchar Bhavan, Bombay was built and set up by the Indian Telephone Industries, Bangalore, and the exchanges, manual as well as automatic by the Posts and Telegraph Department and the Indian Telephone Industries. About 30 Indian manufacturers supplied equipment to the project.

There has been a net saving of Rs. 32 lakhs in the overall cost of the project as compared to the cost of the "turn key" contract to a foreign contractor planned initially. The saving in foreign exchange is about Rs. 45 lakhs. ●

A. E. C. Appointment

Prof. S. Dhawan, Director, Indian Institute of Science, Bangalore, has been appointed a Member of the Atomic Energy Commission for a period of one year with effect from January 1, 1971.

The present composition of the Commission is as follows:

Dr. Vikram A. Sarabhai, Secretary, Dept. of Atomic Energy	*Chairman*
Dr. I. G. Patel. Secretary, Dept. of Economic Affairs, Ministry of Finance	*Member for Finance*
Shri H. N. Sethna, Director, Bhabha Atomic Research Centre	*Member for Research and Development*
Shri P. N. Haksar. Secretary to the Prime Minister	*Member*
Shri J. R. D. Tata	*Member*
Prof. S. Dhawan	*Member*

Shri T. N. Seshan, Director, Department of Atomic Energy. is the Secretary to the Commission.

Pollution Must Be Controlled at Source

(Continued from page 5)

interstate uses of Delaware and Potomac estuaries in the U.S.A., and the Volga-Moscow canal, U.S.S.R.

Silt and heat are physical pollutants demanding attention because of large reservoirs, land erosion, and growth of thermal and nuclear power stations. Thermal pollution can drastically affect ecology and result in extensive fish kill. Silt and thermal pollution can exhibit the phenomenon of synergesis under adverse conditions. Turbidity and sediments are particularly harmful as they eliminate spawning grounds and destroy the habitats of molluscs, shrimp, etc. Silt causes problems of abrasion of bearings and choking of filters in water treatment. It supports concentration of bacterial life, and defies disinfection by chlorination. Silt cuts out light and inhibits faunal growth. It blankets sewage and holds it in position, depleting oxygen in stagnant pools. There is evidence that turbidity can clog opercular cavities and gill filaments of fish.

Water management in most parts of the country is in a sorry state. The quality of public water supply in the country is not well assessed because the machinery for country-wide inspection of water quality is inadequate. Cases are known where waste effluents from paper mills and antibiotics productions have been released into rivers making the water unusable to villages upto great distances. As there is no insistence or legal requirement prohibiting uncontrolled discharges, pollution of water supplies has resulted in the wake of industrial activity and population growth. It has never been well appreciated that all the resultant damage will ultimately sap the vitality and health of the nation. The countrywide pollution has uncontrollably grown because there is no public insistence on payment of compensation for damage resulting from use of polluted water supplies, presence of open municipal drains, and discharge of untreated sewage and industrial effluents. The only significant deterrent for indiscriminate discharges is the polluter's liability to pay for water treatment costs and compensation for personnel and property damage. **The Government efforts to bring legislative control on prevention of pollution of water though belated, should therefore receive highest commendation.** To make the effort truly effective, apart from setting up an efficient implementing machinery, the legislation should include inter alia the following :

(i) a time limit to control existing pollution and bring present discharges under safety limits.
(ii) provide financial support for setting up treatment plants.
(iii) include safety criteria on the basis of established standards (WHO for example) till Indian standards and criteria are evolved.
(iv) penalty to match damage, compensation and costs of treatment of downstream user on the basis of wastes inventories
(v) evaluation of recipient or assimilative capacity of streams (including estuaries) by water movement and ecological studies and
(vi) issue of discharge permits to different installations only within the limits of assimilative capacity.

The basic scientific approach should be to control pollution at source because it is irretrievable and uncontrolled on discharge. ●

Remote Sensing

(Continued from page 10)

dian scientist and an engineer are in Paris engaged in the construction. This instrument will be used for thermal mapping of oceans and land areas from an aircraft platform.

THERE are currently discussions about the sensitivity of individual nations arising from apprehension about the consequences of a satellite remote sensing programme. It is our view that international agencies and individual nations should realise that space technology has come to stay, that the world is shrinking under its impact, and that national boundaries cease to be recognised by high altitude satellites. These have become facts of life. Modern space age will gradually erase national boundaries in social, economic and cultural matters. This is already occuring in Europe and we may expect it to occur in other continents. Global Earth Resources Survey Programmes will hopefully help mankind realise that this is a one world and that its resources are to be used wisely for the benefit of all mankind. ●

IAEA Contract

(Continued from page 1)

This contract Dr. Eklund said was remarkable both because it was the thousandth awarded by IAEA and "because it goes to a developing country in the economic sense and a very developed one in the atomic energy sense." When research contracts were introduced by the Agency about ten years back, most were awarded to institutes in developed countries.

Speaking of the Bhabha Atomic Research Centre in this context Dr. Eklund said. "You have, out of your own efforts, done something most remarkable — you have created a centre of excellence, among the most remarkable centres in this field in the world."

The project, to be undertaken by the Isotope Division of the Bhabha Centre, is an integral part of the Agency's coordinated programme on research on radiopharmaceuticals which is to be carried out in close consultation with the World Health Organisation.

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 1, and printed by him at Conway Printers Pvt. Ltd., 167c, Dr. A. B. Road, Worli, Bombay 18.

Registered No. R. N. 9002/62

NUCLEAR INDIA

Vol. 9. Nos. 9 & 10 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY MAY-JUNE 1971

Atomic Energy—1970-71

IN May 1970, the Chairman of the Atomic Energy Commission announced the principal tasks for the decade 1970-80 for development of atomic energy and space research in the country. A profile of the proposed programme was presented to the Parliamentary Consultative Committee for the Department of Atomic Energy in June 1970. The Committee warmly welcomed the proposals. The Government has accepted the objectives of the specific programmes set out in the Profile.

The Profile involves a commitment to a firm programme which includes, among other things, commissioning by 1980 of 2700 MW of nuclear power, design and construction of advanced thermal reactors (of 500 MW unit size), design and construction of a prototype fast breeder reactor, augmentation of heavy water production, development of gas centrifuge technology for uranium enrichment, and the all-round strengthening of support facilities. This includes development of the Narwapahar uranium mines and facilities for extraction of uranium

(Continued on page 2)

ATOMIC ENERGY ESTABLISHMENTS IN INDIA



10-Year Profile Guideline for Nucle

(Continued from page 1)

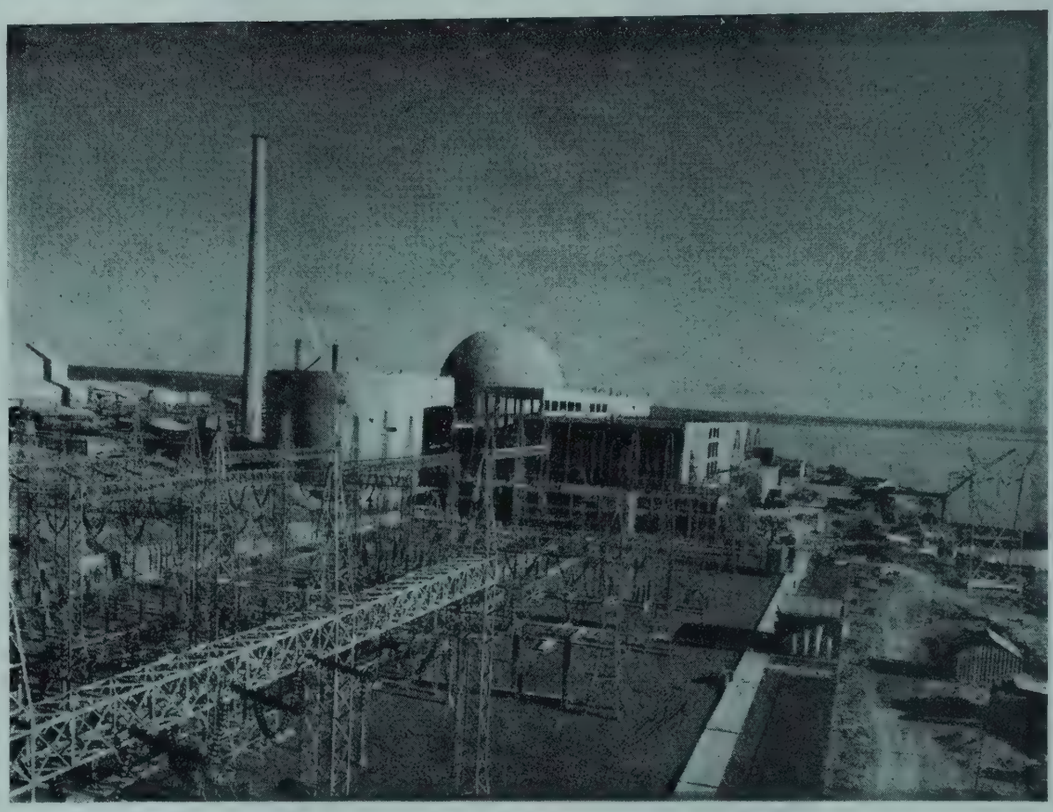
from low-grade ores, early completion of the Nuclear Fuel Complex at Hyderabad for manufacturing special materials and fuel elements, creation of adequate facilities for reprocessing irradiated fuel and for recovery of by-products, and widespread application of isotopes in industry, for food preservation, medicine and research.

The plan for Space Research in the profile envisages creation of facilities for building scientific and communication satellites, and development by 1980 of a capability to launch 500 kg. payloads into synchronous orbits. The first step will be the development of a four-stage launcher burning solid propellant, capable of putting into orbit a satellite of 30 kg. payload. This would be followed by the development of more advanced rocket systems.

The programme also includes augmentation of R & D facilities at the Space Science and Technology Centre at Thumba, development of inertial guidance systems and on-board miniaturised computers, development of the Sriharikota rocket range on the east coast for satellite launchings, establishment of facilities for production of large size solid propellants for rocket boosters, fabrication of rocket casings and hardware for rocket motors, etc., and the development of sensors and techniques for remote sensing.

The Department concentrated its efforts during the year in pressing ahead with existing major schemes and in preparing the groundwork and drawing up of detailed operational plans for fulfilling the objectives set out in the Profile.

The Department's total earnings from sale of goods (including nuclear power) during the year amounted to about Rs. 22 crores. This reflects the commencement of a new phase of the atomic energy effort in the country in which practical benefits are now accruing to the nation.



Construction scene at the Rajasthan Atomic Power Station site near Kota.

Nuclear Power

By the end of March 1971, the Tarapur Atomic Power Station completed more than seventeen months of satisfactory commercial operation, generating over 3,750 million units of electricity. During the year ending March 31, 1971, the Station generated over 2,400 million units. Of this Maharashtra utilized 1,153 million units, while Gujarat was able to absorb 1,092 million units. The availability of power from the Station ensured that there was no power cut in Maharashtra in 1970 even in the pre-monsoon months. The Station is being operated as a commercial undertaking, and the rate at which power is being sold is fully competitive with power rates of conventional stations in the region. During the first complete year of operation, the Station had a small net surplus after making full provision for depreciation and interest charges. To manage the affairs of the Tarapur Station, and other atomic power stations as they become operational, the Department has constituted an Atomic Power Authority.

Two other nuclear power stations — the Rajasthan Atomic Power Station (being built with Canadian assistance) at Rana Pratap Sagar near Kota, and the Madras Atomic Power Station, being built wholly by Indian engineers and scientists at Kalpakkam near Madras, are under construction. The first unit of the Rajasthan Station is expected to become critical towards the end of 1971, while the second unit is expected to reach this stage in 1974. At the Madras Station, construction work, which is behind schedule, is now acquiring momentum and fabrication of nuclear equipment is in progress. It may be noted that many sophisticated items of nuclear equipment are being manufactured in India for the first time. The task therefore involves not only the building of a nuclear power station, but the creation of a national capability in this field.

Space Effort

New Nuclear Power Stations

A perspective planning study for electric power development for the whole of India over the next 25 years has been carried out jointly by members of the Programme Analysis Group of the Department, and the Computer Group in the Tata Institute of Fundamental Research.

A dynamic linear programming model was developed for this purpose. The model took into account such factors as growth of demand for electricity, fuel cycles, fuel availability, etc. and sought to minimise the total discounted cost of meeting the demand from all the types of plants — nuclear, thermal and hydel over the planning period. The results of the study indicate that in Northern, Western and Southern regions of the country, nuclear plants would be economically worthwhile and that by 1991-92 the total nuclear generating capacity should be 10,500 MWe. The total savings discounted to 1970-71 at 10% per annum, resulting from the nuclear programme outlined in the study, amount to over Rs. 1,000 crores compared with a power programme in which these nuclear plants are replaced by coal-based plants.

In a recent optimization study made to meet the needs of the Northern Electricity Region in 1978-79, the economic advantage of having two nuclear power stations of 400 MW each has been established.

Advance action for setting up new nuclear power stations has been taken. A site selection committee was appointed by the Department in September 1970 to examine suitable sites in the northern, western and southern regions. A site in the northern region is expected to be identified in 1971.

Heavy Water

Considering the long-range requirements of the country's nuclear power programme, three plants for the production of heavy water have been sanctioned by Government. The plant at Kota based on the H_2S- H_2O process developed at the Bhabha Atomic Research Centre is expected to be ready by 1974. The plants at Baroda and Tuticorin, based on the ammonia-hydrogen exchange process developed in France and linked with the ammonia streams of fertilizer plants are likely to be commissioned in 1973 and 1974 respectively.

Nuclear Fuel

The Atomic Fuels Division of the Bhabha Atomic Research Centre is engaged in developing and fabricating fuel elements and associated components for research and power reactors. It is fabricating half the initial fuel charge for the first unit of RAPP. The Division has also supplied thorium metal blocks and strips to the Julich Atomic Research Centre in West Germany under a collaborative arrangement.

The process know-how and production technology developed at the Division are being used to build the Nuclear Fuel Complex at Hyderabad which will meet the needs of the planned nuclear power plants besides the ones under construction.

The construction work at the Nuclear Fuel Complex is making satisfactory progress. All the plants except the Enriched Uranium Oxide Plant and the Enriched Fuel Fabrication Plant are expected to be commissioned before the end of 1971. These two plants will become operational by mid-1972. Government has recently approved that alloy steel extruded tubings should also be manufactured at NFC.

A Special Materials Plant is being set up as part of the Nuclear Fuel Complex. This plant, being built on the basis of know-how developed at BARC, will produce ultra pure metals and materials to meet the demands of the electronics industry.

Fuel Reprocessing

The knowhow and technology developed at the Fuel Reprocessing Division of BARC on the recovery of plutonium from irradiated fuels and the experience gained with the reprocessing plant at Trombay form the basis of the Power Reactor Fuel Reprocessing Plant being built at Tarapur. Construction of this plant is making good progress.

At this Division, a pilot scale solvent extraction unit for the recovery of uranium-233 from irradiated thorium has been commissioned. The separation of uranium-233 from irradiated thorium is being done on a continuing basis and the chemical and isotopic purity of uranium-233 thus obtained is very satisfactory.

Agro-Industrial Complex

The Working Group for studying the techno-economic feasibility of establishing Agro-Industrial Complexes around low-cost nuclear energy units has completed its detailed examination related to two locations — one in Western Uttar Pradesh, and another in the Kutch-Saurashtra region of Gujarat. On the basis of the recommendations of the Group, further work has been initiated on setting up pilot farms, investigations of underground water resources, pilot studies on desalination techniques, etc.

Research work relating to desalination is being conducted by the Desalination and Effluent Engineering Division of the Bhabha Atomic Research Centre. This Division has recently developed double-fluted tubes, the use of which is likely to result in significant savings in the costs of desalination.

Reactor Research Centre

Considerable progress has been made in setting up the Reactor Research Centre near Kalpakkam. The Centre will be responsible for the development, in all aspects, of fast reactors and such other reactor systems as may be assigned to it. The first phase of the development programme includes (a) the design, construction and operation of a prototype fast reactor, (b) the construction and operation of

(Continued on page 4)

All-Round Increase in Nuclear Activities

(Continued from page 3)

a pulsed fast reactor and (c) the building-up of the infrastructure for research and development related to these and associated activities.

Variable Energy Cyclotron

A Variable Energy Cyclotron is being set up as a national facility near Calcutta by the Bhabha Atomic Research Centre. This will be a modern research facility for high quality work in nuclear physics, and controlled direct irradiation of biological and agricultural products. Because of its high beam intensity, the cyclotron can produce a variety of isotopes which it is not possible to produce in nuclear reactors. The proposed facility will also provide new opportunities for research workers from the universities which by themselves may not be able to set-up and operate a large and complex machine of this type. The main magnet for the cyclotron, weighing 250 tonnes, will be cast and machined at the Heavy Engineering Corporation, Ranchi while the coils of the main magnet will be fabricated by the Heavy Electricals, Bhopal. The power supplies, radio frequency system, vacuum equipment and other ancillaries will be fabricated at Trombay.

Atomic Minerals

Location of atomic minerals and research and development work for exploiting them is undertaken by the Atomic Minerals Division of the Department. The year witnessed an all-round increase in the level of activity of this Division. Underground development work continued both at Narwapahar and Bhatin in the Singhbhum Thrust Belt of Bihar. Besides this work, exploration in other areas, such as the Betul district of Madhya Pradesh and the Chamoli district of Uttar Pradesh, was continued. Investigations for uranium were intensified in the Himalayas as well as in Peninsular India. Besides uranium, the Division continued its work of reassessment of beach-sand deposits of heavy minerals like ilmenite, rutile etc. in Kerala, Tamilnadu and Orissa. The Orissa deposits are very promising, and the Department is studying the techno-economic feasibility of setting up mineral sand separation and processing facilities based on these.

Detection of Nuclear Explosions

At the Gauribidanur Seismic Array near Bangalore almost all the underground nuclear explosions from the Russian region, as well as the major ones from the Nevada test site of the USA were detected. The array also detected the latest Chinese explosions, their location, time and yield.

Radioactivity Monitoring

The Bhabha Centre continued detailed fallout measurements at the countrywide network of stations maintained by it. Detailed analysis of samples of high altitude dusts in connection with the series of French and Chinese tests of 1970 were carried out.

The Health Physics Division of BARC continued monitoring of marine environment off Bombay and Tarapur for assessing the distribution of radioactivity.

Radiation Protection

The Directorate of Radiation Protection at the Bhabha Atomic Research Centre, Trombay, which is responsible for implementing a countrywide

(Continued on page 5, col. 3)

Industrial Operations Show

THE industrial operations of the Department support the atomic energy programme. There are three public sector undertakings under the administrative control of the Department: Uranium Corporation of India Ltd., (UCIL), at Jaduguda, Indian Rare Earths Ltd., (IRE) at Bombay, and the Electronics Corporation of India Ltd., (ECIL), at Hyderabad.

During the year, the facilities at UCIL worked at full-rated capacity and produced uranium concentrates worth Rs. 375 lakhs, as against production valued at Rs. 341 lakhs in the previous year. The net operating profit for the year after providing in full for depreciation and interest is likely to exceed Rs. 30 lakhs.

To meet the upward trend in the international rare earths market, the capacity of the rare earths plant of Indian Rare Earths Ltd., at Alwaye was increased to treat 4500 tonnes of monazite per year. Almost the entire production of rare earths is exported and the Company has entered into contracts with its associates in Europe and Japan till December 1971, and with its associates in the USA till December 1973, for the sale of rare earths chloride.

With improvement in operational techniques and by addition of a few items of equipment, it was possible to increase the capacity of the Manavalakurichi plant of the Company to treat 400 tonnes/day of raw sand. This would result in an increase in the production of ilmenite to 60,000 tonnes/annum at Manavalakurichi with corresponding increase in other minerals. During 1970-71, the main mineral sand separation plant at Chavara, with capacity to treat 650 tonnes/day of raw sand, the zirconium opacifier plant nearby, and the zirconium oxide plant at Manavalakurichi, also went into operation. The Company's production of ilmenite is fully committed for sale till the year 1973-74. The Company's total turnover in 1970-71 was approximately Rs. 236 lakhs, of which foreign exchange earnings amounted to Rs. 124 lakhs. The net profit for the year is likely to exceed Rs. 15 lakhs.

Radioisotopes—Production, Applications...

DEVELOPMENTAL activities in the area of production and application of radioisotopes continued at the Isotope Division of BARC. During the year, the curie value of radiation sources supplied by BARC went up to 40,000 as against 12,000 supplied during the preceding year. The Division also fabricated gamma chambers of 4000 cc. capacity against the earlier 900 cc. capacity units it was marketing. The Division is also working on the development of procedures for production and control of short-lived radiopharmaceuticals under a contract with IAEA.

Biology and Nuclear Medicine

At the Biology Division of the BARC, among other investigations, plant breeding programmes were continued. Several groundnut mutants were tested at Trombay for yield and oil-content. In the All-India Co-ordinated Trials, TG-1 and TG-3 gave high yields in Punjab and Madhya Pradesh respectively. TG-1 was recommended for pre-release multiplication.

The Biochemistry and Food Technology Division of BARC continued its research programme on basic and applied aspects of cellular metabolism and the development of food irradiation procedures. Work in food technology related primarily to the development of promising radiation preservation procedures for perishable foods. Large scale feasibility trials on disinfestation of wheat, extension of storage-life of onions, and preservation of fish and fish products are under way.

The Radiation Medicine Centre of BARC is engaged in research towards the application of radioisotopes in medicine, for diagnosis and therapy etc. The Centre is the largest single user of radioisotopes in the country in this area. The impact of nuclear medicine in facilitating the diagnosis and treatment of various disease conditions can be gauged from the fact that the number of radioisotope investigations per 1000 of the population of Greater Bombay has been estimated to be 3 as against 0.05 for the rest of the country. Plans are being finalised to extend the benefits of radiation medicine to other areas of the country. The RMC has an extensive programme for development of new radiopharmaceuticals for organ scanning, and also conducts training courses on the medical uses of radioisotopes. In collaboration with the World Health Organisation and the International Atomic Energy Agency, the Centre conducts a training course in radiation medicine techniques for medical personnel from India and other developing countries.

The Tata Memorial Centre at Bombay, for which the Department is administratively responsible, undertakes study and research in surgical, medical and allied fields pertaining to cancer, as also treatment of cancer patients and training of physicians and investigators in the area. The Centre incorporates two institutions: the Tata Memorial Hospital and the Cancer Research Institute, which were merged in 1967. A specialized institution like the TMC offers unique opportunities for the innovative adoption of many and varied application of nuclear technology in research, diagnosis, and therapy of cancer and allied diseases. It has contributed very substantially towards fostering multidisciplinary efforts for affording such benefits to the community, which radiation medicine alone can offer in the alleviation of human distress.

Effects of radiation on physical as well as biological properties of macromolecules is another area of interest for the Department. The importance of these studies cannot be overemphasized in view of the increasing use of radiations for sterilization of medical products. As a first step in the Department's efforts to promote the beneficial effects of radiation in the field of medical products, a demonstration facility for radiation processing of medical supplies such as cottonwool, guaze, sutures, talc etc. is being established at Trombay with assistance from the UNDP. It is expected to be commissioned by the end of 1972. ●

Steady Growth

A notable feature of the Electronics Corporation of India Ltd. is that indigenously developed expertise is exclusively used for the production of sophisticated professional grade components, equipment and systems. The Company has completed the first phase of establishing manufacturing facilities, stabilising production processes, and securing a footing in the market. It has successfully productionised analogue and digital computers and has marketed three units in 1970-71. The Company has also developed a fully transistorized closed circuit TV system and a prototype commercial TV set. The Company has earned a small profit during 1970-71, the third full year of its operation. Sales increased from Rs. 9 lakhs during 1967-68 to over Rs. 175 lakhs in 1970-71.

The Company has finalized plans for major expansion and diversification in the next five years including the establishment of an indigenous base for national computer needs. ●

Radiation Protection

(Continued from page 4)

radiation hazards control programme, expanded its activities considerably during the year. The countrywide personnel monitoring service of the Directorate now covers nearly 21,000 radiation workers from 1,450 institutions. As part of the countrywide hazards control and evaluation programme, the Directorate conducted radiological protection surveys in 114 institutions, which include medical, industrial, agricultural and research institutions. ●

A BROAD-BASED programme in Space Research was pursued actively. It covered: (1) Space Sciences, through research in aeronomy, X-ray and Gamma-ray astronomy, plasma physics, cosmic rays, studies of lunar material and meteorites etc; (2) Space Technology, which includes all aspects of work related to the development and building of rockets, satellites, scientific payloads as well as ground and space instrumentation; and (3) Space Applications, such as satellite telecommunications, space meteorology and remote sensing of earth resources.

Space Sciences

Basic research in Space Sciences is being carried out at the Physical Research Laboratory (PRL) at Ahmedabad, at the Tata Institute of Fundamental Research (TIFR) at Bombay, and the Space Science and Technology Centre (SSTC) at Trivandrum.

Scientists at the Physical Research Laboratory, Ahmedabad carried out investigations for the study of the ionosphere in the equatorial electrojet region and at low latitudes. The electrojet studies were mainly conducted with the help of payloads designed and developed at the Laboratory and flown from the Thumba Equatorial Rocket Launching Station (TERLS). Some of these rockets were fabricated in India. Others were supplied through collaborative arrangements with the National Aeronautics and Space Administration (NASA) of the USA, the Hydrometeorological Services of the U.S.S.R., and the Science Research Council (SRC) of the UK. The main objectives of these rocket investigations were:

(i) to investigate the ionization irregularities and the plasma instabilities in the equatorial ionosphere.

(ii) to study the electric and magnetic fields in the equatorial ionosphere and the electrojet.

(iii) to investigate the effect of cosmic rays on the ionization in the lower ionosphere by simultaneous flights conducted at Thumba and in the Hebrides by British scientists.

(iv) to study the winds and temperature in the equatorial neutral upper atmosphere.

Continuous sounding of the ionosphere was undertaken by ground-based equipment using ionosonde and riometers. Signals from Beacon Satellites were received to study the total electron content in the ionosphere. Special equipment, gifted by NASA, for commanding an Alouette-type satellite for sounding the ionosphere from above is being installed. It will enable the Laboratory to obtain data from about fifteen satellite passes a week.

A group of scientists at PRL continued their study of the data obtained about the interplanetary medium from satellites IMP-1, IMP-3 and Explorer-33. Their studies have shown that the perturbations of the geomagnetic field can be used effectively to probe the electromagnetic condition of interplanetary space. Large area scintillation telescopes registering cosmic ray intensities from vertical and inclined directions have been set up at the Laboratory to study the anisotropy of galactic cosmic radiation. Data collected from these telescopes are analysed in conjunction with neutron monitor data collected at Ahmedabad and Gulmarg.

Results of a number of rocket flights conducted for X-ray astronomy studies from the Thumba Rocket Range and collaborative flights conducted in Japan by the University of Tokyo scientists have been studied in detail. These results have also been correlated with optical observations and balloon studies. They have re-

SPACE RESEARCH



vealed the nature of the Scorpio X-ray source and the results are consistent with its being a white dwarf of approximately solar mass.

At the TIFR, investigations are being carried out using a large number of meteorites and a few dozen samples of rock-finds returned on the Apollo-11 and 12 Moon missions to look for vestigial records of Superheavy transuranic nuclei.

TIFR scientists conducted two high altitude balloon experiments for X-ray astronomy studies. The results established the position in the sky of the new high galactic latitude X-ray source TWX-1. This source was discovered last year by the same group. Studies for the detection of very high energy electrons in the cosmic rays conducted with the help of emulsions-lead sandwich stack exposed at high altitudes have shown 100 very high energy events involving electrons of energies greater than 100 GeV.

The Balloon Launching Facility is located at a distance of 16 km. from the city of Hyderabad and is operated by TIFR, Bombay. During the last year, the remaining buildings of the facility were completed and the facility became fully operational in September 1970, when balloon production also was shifted there. Last year ten polytheylene balloons of upto 84,900 cu. m. volume were launched to altitudes of upto 35 km for various studies, by different research groups from India, Japan and the USA.

Space Technology

The Indian Space Research Organisation (ISRO) is responsible for the management and execution of space research activities undertaken on behalf of the Department of Atomic Energy (DAE), Government of India. It provides rockets and laboratory facilities to project scientists of different organizations to conduct approved experiments. Different projects utilizing space technology for development have been undertaken by ISRO. Presently fourteen units are functioning under ISRO in different fields of space research.

The Thumba Equatorial Rocket Launching Station, located near Trivandrum city in Kerala State became operational in November 1963, and has since been serving as the Indian rocket launching facility for the space research programme. It was dedicated to the UN in February 1968, and is enjoying UN sponsorship in accordance with the recommendations of the UN Committee on Peaceful Uses of Outer Space. It serves as an international range and is open to the world scientific community for conducting scientific experiments. During the year 1970-71 more than 172 rockets, including test rockets, have been launched from TERLS. This reflects the growing tempo of space activities arising from indigenous development of the technology of rockets.

At Sriharikota on the east coast, about 60 km. north of Madras, the first phase of work, namely, setting up of a sounding rocket launching pad, vehicle preparation room, instrumentation room for housing ground support equipment etc., is under way. The second phase of work, which includes additional facilities, is expected to be ready by 1972. In the third phase of the programme, special facilities will be built for satellite launching.

Special Facilities

The Space Science and Technology Centre on Veli Hill near Thumba, does research and development in all fields of rocketry including control and guidance systems and electronics for telemetering scientific data. During the year, it developed a digital computer programme in collaboration with TIFR to predict the trajectory of multistage satellite launch vehicles. Special facilities have been created at SSTC for the development of propellants and hardware for large diameter rockets. Development of rocket chambers using reinforced glass fibre is under way and these have been tested under simulated loads and pressure.

One of the most important tasks of the Centre is to develop indigenously a satellite launch capability. A four-stage launcher vehicle designated SLV-3 is being designed for this purpose. Solid propellants of high performance required for the launcher are now being produced at SSTC and these have been flight-tested in smaller rockets.

India's first successful prototype of a rate gyroscope, an instrument to measure the rates of angular motion of space vehicles in flight—has been developed at SSTC. It forms an integral part of the autopilot system of aircraft and rockets and is used to measure the angular deviation rates of the vehicle as well as to control and adjust its orientation. This development marks a major step in India's efforts to acquire inertial guidance capability and will be of great value for use in the satellite launch vehicle.

The first flight of the Centuare sounding rocket charged with propellant grains made in the Rocket Propel-

1970—71



ONAL BALLOON LAUNCHING FACILITY

UNCHING STATION
PELLANT PLANT
T EVALUATION COMPLEX

Efforts to Develop Satellite Launch

(Continued from page 7)

lant Plant (RPP) at Thumba was successfully conducted in December 1969, and regular production of propellant grains for Centaure rockets is continuing. Facilities at RPP are currently being extended.

A Rocket Fabrication Facility was commissioned at Thumba in January 1971. The facility will manufacture Centaure, Rohini and Menaka rockets. Plans have been completed for expanding this facility to manufacture hardware for the satellite launch vehicle.

Space Applications

The fourth international course in Satellite Communication Technology was conducted at the Experimental Satellite Communications Earth Station, Ahmedabad, The Arvi satellite communications earth station near Poona was completed by the Department and handed over to the Overseas Communications Service on January 31, 1971. In executing this sophisticated project, the Department assumed a unique role; namely that of the prime contractor. The Department had earlier acquired considerable know-how and expertise by building and operating the Experimental Satellite Communications Earth Station at Ahmedabad. The most important single item in the Arvi station, namely, the 29.56m steerable parabolic antenna was completely fabricated in India. There has been a net saving of about Rs. 30 lakhs in the overall cost of the project as compared to the 'turn-key' contract to a foreign contractor originally proposed. The saving in foreign exchange is about Rs. 45 lakhs. Performance tests have borne out the high level of indigenous expertise invested in the project: the station in some ways exceeds INTELSAT requirements.

To meet the large demand within the country for microwave antennae of various types by the space research programme as well as by other Government departments, a Microwave Antennae Systems Engineering Group (MASEG) has been set up by the Department. MASEG is responsible for research, development and design of microwave antennae systems in collaboration with TIFR and ESCES. The Electronics Corporation of India Ltd. markets complete antennae according to customer's requirements. Presently, most of these systems are imported.



The 29.56 metre diameter antenna of the Arvi Satellite Station near Poona.

As mentioned in last year's annual report, an agreement was signed in September 1969 with NASA of the USA for the use of its ATS-F satellite for a period of about one year to conduct a joint Satellite Instructional Television Experiment (SITE). A Special SITE Group has been set up in ISRO to undertake overall responsibility for the experiment. The Information and Broadcasting Ministry and other ministries interested in the use of TV for national development have taken steps to provide necessary inputs for SITE. The experiment will commence about mid-1974 and will involve the broadcasting of Indian instructional television material to about 5000 villages in different parts of the country. The Experiment will be the first ever test of broadcasting signals directly to augmented

Capability

TV receivers without going through the intermediary stage of a terrestrial TV transmitter. About half the sets will be of the direct reception type and can accordingly be located in the remotest areas in the country without economic penalty. The systems management and planning of the ground segment required for the Experiment will be looked after by the Electronics Systems Division (ESD) of ISRO.

The Experimental Satellite Communications Earth Station (ESCES) will be used for transmitting instructional TV programme material from programme originating centres of AIR to the satellite and for monitoring these transmissions and the performance of the spacecraft for the duration of the experiment. For this purpose, ESCES is being modified and the UNDP is providing assistance in the form of components and expertise.

Television Coverage

In the past few years, ISRO has conducted systems studies to examine the implications of using geostationary satellites for national telecommunication requirements including television coverage. In the second half of 1970, a joint study was conducted with the Massachusetts Institute of Technology in the USA. The ISRO-MIT (INSAT) study, unlike previous ones, examines an optimal systems design and estimates cost of an Indian National Satellite (INSAT). The satellite design that has been achieved in this study provides three active (one back-up) transponders for direct broadcast of television. In addition, there are four television-distribution transponders. There are also six telecommunications transponders mainly to cover .the trunk-tele-traffic between our four metropolitan areas by providing 1800 high quality telephone circuits. The two high-powered multiple access transponders on INSAT will be able to provide most flexible random-access (demand-assignment), point-to-point communication capability with relatively simple and inexpensive ground equipment. Currently, a detailed evaluation of the utilisation pattern of the telecommunications satellite is underway in collaboration with the Ministry of Communications.

Under a meteorological rocket-sonde programme executed jointly with the United Kingdom, ten Skua rockets were launched from Thumba during March 1970. For the first time, temperature data were obtained between 25 km and 60 km over Thumba. Under a joint Soviet-India programme, Soviet meteorological rockets are being launched, one each week, over a period of two years. The launching commenced in December 1970. In this programme, it is planned ultimately to get synoptic data of the upper atmosphere along meridional cross section extending from Siberia in the North to Antarctica in the South, including points in the Indian Ocean.

A small remote sensing project on the early detection of the coconut blight disease has been successfully conducted in Kerala, where we have the largest area under coconut plantation. The plantations are affected by wilt (root) disease resulting in an annual loss of about 10 million rupees. The disease is characterised by symptoms of "wilt" accompanied by flaccidity and abnormal bending of leaves. Systematic investigations have proved that the disease is caused by rod-shaped virus particles. Under an ISRO-NASA joint project, coconut plantations with healthy and unhealthy trees were photographed from the air using infrared sensitive colour films as well as panchromatic colour films. A helicopter flying at an altitude of about 600 meters served as the aerial platform. Since a significant fall in the infrared reflectivity occurs in the early phase of the disease, infrared photography enables early detection and suitable remedial action to be taken. By the use of this new technique, there is a promising possibility of detecting the wilt disease even before visual symptoms appear.

ISRO engineers are constructing an infrared scanning camera at the Laboratories de Meteorologie Dynamique—CNRS in Paris, France. This instrument, when ready, will be used for thermal mapping of oceans and land area from an aircraft platform. Used in conjuction with cameras, recording in the visible, this instrument will be useful for soil surveys, crop discrimination and even some geological work.

International Relations

THE Department of Atomic Energy continued to participate in all the important activities of the IAEA. For the fourteenth year in succession since the inception of the IAEA, India, as the country most advanced in atomic energy in South Asia, was designated a member of its Board of Governors. The Department has also been actively participating in the work of the United Nations Outer Space Committee and its sub-committees.

India is participating in the computer-based International Nuclear Information System (INIS) established by the IAEA in Vienna. The Library and Technical Information Section of BARC is responsible for preparing the national inputs for this system. According to a survey made by the Section, India produces annually around 12,000 papers, reports, theses, etc. of a scientific and technical nature. Of these about 3000 fall within the INIS subject-scope which is about 3% of the nuclear literature produced in the world. The Indian input for the INIS so far is about 3%.

For the 14th regular session of the General Conference of IAEA held in September 1970, Dr. Vikram A. Sarabhai, Chairman, Atomic Energy Commission was unanimously elected President. India's Resident Representative at the Agency, Ambassador V. C. Trivedi was unanimously elected Chairman of the Board of Governors for the year 1970-71. ●

The object of forensic science is to try to make sure that the guilty are found out, and that the innocent are protected. One technique which can be used by the investigator is neutron activation analysis.

JUSTICE

ACTIVATION ANALYSIS is a nuclear technique used for identifying and assaying the amounts of certain elements in samples which may be almost too small for the eye to see. It is in wide use in the laboratory, and is being used increasingly in industry, medicine and elsewhere as a routine technique. In appropriate cases, activation analysis is used for the purpose of obtaining proof in criminal cases in at least five laboratories — three in the United States, one in Canada and one in the United Kingdom.

The name given the technique cloaks a simple method of operation. In one form of the technique which is in fairly common use, a sample is bombarded with neutrons inside a nuclear reactor. Radioactivity is thus induced in certain elements, and by using instruments to study the way they behave in this "activated" form they can be identified and measured in extremely small quantities.

This is, of course, only one of many techniques used in forensic work. For fairly large samples other physical and chemical techniques can be used. But activation analysis is extremely versatile and can be used in the assaying of samples of widely differing kinds without destroying them — often an important factor. It has one big disadvantage: it is not the kind of technique which can be used in the back room of a police laboratory. The sample must be irradiated, for the particular form of activation analysis being discussed here, inside a reactor; and if a police department were to wish to use this technique they would have to send a sample away to a laboratory which has suitable facilities.

Why, then, use this technique at all, if it requires such facilities? The answer to this question lies largely in the great sensitivity of the method. It may not be faster or more economical than other methods of analysis, but it makes possible analyses which can not be performed in other ways, and may give greater certainty. Some aspects of the use of activation analysis in forensic science were described by Professor V. P. Guinn, of the University of California, Irvine, in the United States, during a recent visit to IAEA headquarters in Vienna. Prof. Guinn is a leading authority on the subject of activation analysis, and has had for some years a special interest in forensic work.

It is possible to detect a few elements in samples, he said, in quantities as small as one ten-millionth part of a microgram; a few can be detected only in amounts greater than about ten micrograms. The midrange of sensitivity falls at about a thousandth of a microgram.

Range of Sensitivity

It is this great sensitivity which made activation analysis especially suitable for analysis of the sort of samples which might be found in forensic work. No criminal is likely to leave at the scene of his crime anything which he knows might be used to identify him; even if he attempts to remove clues to his identity he is likely to leave a hair or two, a scrap of fingernail, a trace of tobacco. When he is caught, ordinary techniques of criminal investigation may be enough to link the colour and formation of his hair with a hair he is thought to have left behind, his blood type may match a smear found at the scene, and so on. Neutron activation analysis may harden suspicion of his guilt to virtual certainty. No two individuals are alike in their actual body composition — particularly in the quantities of trace elements their bodies contain. A sample found at the scene of the crime, which may be very small, may be matched for its content of each of several elements with that of another sample, taken from the suspected source. The result of the analysis may convict or aquit.

Each sample can be analysed for more than one element. Prof. Guinn put it in this way: "The principle used in comparing specimens is through their composition. Let us say you are examining samples of hair in a criminal case. If those two samples came from one particular person they should be quite closely similar, quantitatively, in all the elements you can detect in them. It is more or less like comparing fingerprints, trying to get as many independent points of comparison as you can. We have a lot of background data, and have some basis

of comparison. In hair from different people you will find many of the same elements, it is true, but the concentrations will vary quite widely.

"It may well be that quite a number of people in this lecture room would have the same amount of chromium in the hair, but most people would be outside the range of a particular sample in one direction or another. It is the same for cobalt, the same for scandium. If you get enough elements to compare, it becomes possible to find out whether hair found at the scene of a crime came from one particular suspect."

Prof. Guinn pointed out that this sounded as though it might take some time, but it is in fact quite a quick procedure. Each sample is handled in the same way, and a computer can be used to process many of the results. The difficulty when analysis has been completed is to assess the validity of the conclusion reached : how certain can a forensic scientist have to be ? Cases where activation analysis might be used tended to involve serious offences such as murder, for which a suspected person's life or liberty was at stake.

Probability of Coincidence

"So, you look at the background data and calculate probabilities", said Prof. Guinn. "What is the probability that, really, these two samples came from different people and just happen to be alike ? That is relatively easily done. You can calculate a probability of accidental coincidence. In one recent case in Michigan, by working through the numbers, it came out that 'yes, there was a possibility that the samples being compared really did not have the same origin.' But that probability was rather small — it was about one in a million.... That is the approach one takes. You do not say, finally, with absolute certainty, without any doubt whatsoever, that this sample came from that person. All one can do legitimately, and this is true of all forensic work, is to draw a statistical conclusion and try to establish whether the probability is very

(Continued on page 12)

Answers in Parliament

Construction Schedule of Nuclear Plants

The construction of the Rajasthan Atomic Power Station is proceeding in accordance with the schedule announced last year. The schedule for the first unit of the Madras Atomic Power Project has slipped by approximately one year.

The expected criticality dates of the units of these Projects are as follows :

Projects & Unit	*Expected criticality date*
RAPP I	1971
RAPP II	1974
MAPP I	1975
MAPP II	1976

Full commissioning can be expected a few months after criticality.

(Rajya Sabha, May 27)

DAE - NASA Agreement

The Government of India and the National Aeronautics and Space Administration of USA signed a Memorandum of Understanding on September 18, 1969 for a collaborative experiment to be undertaken in 1974 to test the feasibility of direct broadcast of television from a synchronous satellite to augmented television receivers for community viewing in isolated villages. Government is also studying the feasibility and cost effectiveness of an Indian National Satellite for communication which could provide on-going service for T.V. as well as point-to-point communications including telephones

(Lok Sabha, June 2)

Cost of MAPS

The estimated cost of the second unit of the Madras Nuclear Power Station is Rs. 70.63 crores. The entire output of the first unit as well as half of the output of the second unit will be made available to Tamil Nadu. The balance output of the second unit will be earmarked for the neighbouring States in the Southern Region.

The first unit is expected to attain criticality by 1975 and the second unit in 1976. Full commissioning can be expected a few months after criticality.

(Rajya Sabha, June 3)

Uranium Investigations

Some occurrences of uranium have been found in Betul, Drug, Raigarh and Sarguja districts of Madhya Pradesh. Investigations to prove the nature and extent of these occurrences are in progress.

(Lok Sabha, June 9)

Indo-German Cooperation

Negotiations have been in progress between the West German Government and India for co-operation in the field of peaceful uses of atomic energy. An agreement is expected to be concluded shortly.

A team of nuclear scientists from the Federal Republic of Germany visited India during March 1971 in connection with the Indo-German seminar on Nuclear Fuel Cycles held at the Bhabha Atomic Research Centre in Bombay.

(Lok Sabha, June 16)

Nuclear Policy

The present policy of the Government is to develop scientific and technological capability in the field of space and nuclear energy for peaceful purposes only. This is in the best overall interest of the country and has been reiterrated on several occasions. However, Government keep their policies in this matter, as in others, under constant review, taking into account the interest of national security and defence.

(Rajya Sabha, June 17.)

Justice

(Continued from page 11)

high or very low that the two samples you are examining came from the same source. In the same way, you can say that they did not."

Prof. Guinn took hair as his first and prime example, but he pointed out that the same technique could be used in the analysis of marijuana, opium, paint marks or scrapings and so on, tracing each sample back to its suspected source; or, again, showing that the source was not the one suspected. The technique could be used, as well, in work such as that done in the prosecution of the illegal production of alcoholic liquor, which is known in parts of the United States as "moonshining".

Toxic Whiskey

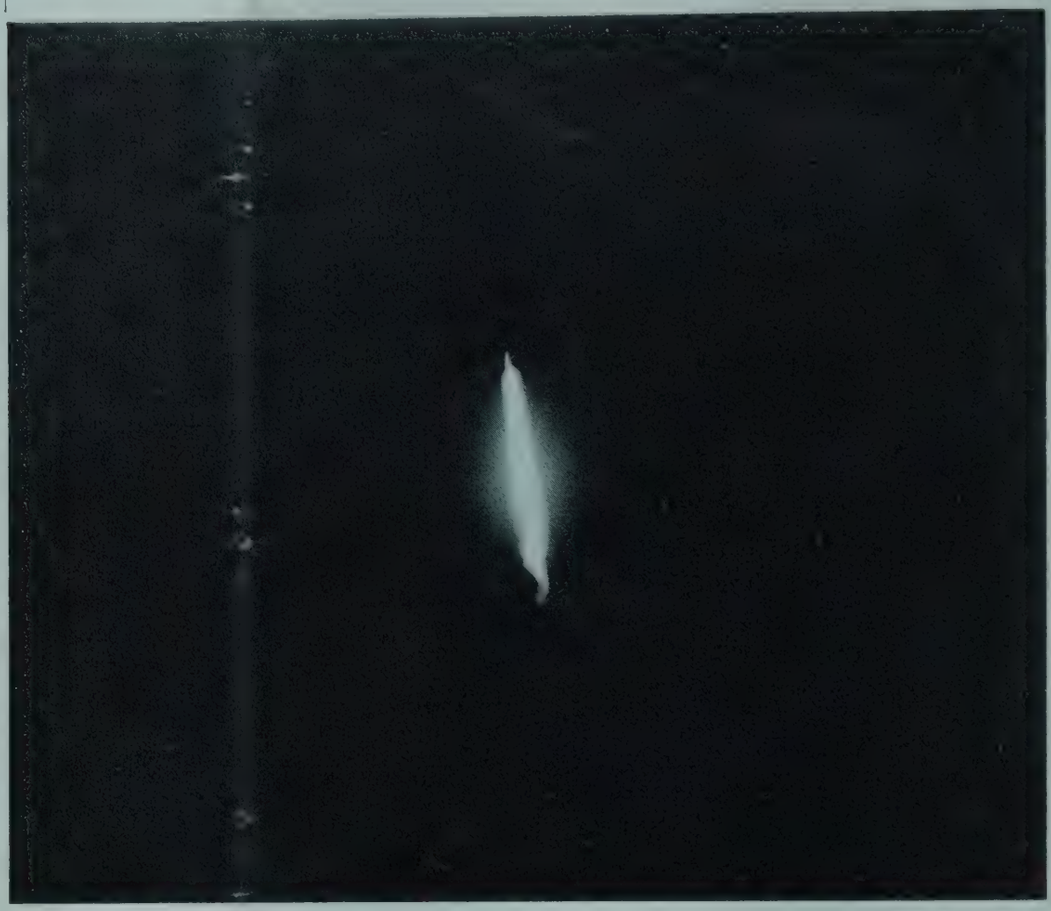
"The US Treasury Department, more than my own group, has had quite a lot of experience in looking at moonshine whisky, non-taxed whisky," he said. "When some of this stuff is picked up, the Department wants to prosecute somebody for making it. So the question arises, can you prove that this whisky was produced at a particular illicit distillery, in the hills?

"When you look at the sample using activation analysis, you can find almost the whole periodic table of elements. The producer's quality control leaves something to be desired. When you look at the still itself you can see why. To distill moonshine whisky they use whatever materials they have to hand — a car radiator, copper pipes for plumbing, lead pipes, galvanised metal, anything they can put together to make a still.

"In one analysis we found as many as 30 elements in the sample. Correspondingly, in good whisky you may find traces of as many as five elements only. The Treasury Department, once when they were looking just for lead traces, were amazed. They found 30 parts of lead per million in the whisky. You could not really drink too much of that. You could kill yourself."

(Courtesy: IAEA Bulletin, Vol. 13, No. 2, 1971)

M-100 Rocket from Thumba



A Russian-made M-100 rocket carrying instrumentation for measurement of temperature, pressure and wind speeds streaks across the Thumba sky.

DAE Seminar for Executives

FOR the first time, senior executives of all the units of the Department of Atomic Energy had an opportunity to discuss management problems of interest to them. A Seminar on Some Management Concepts was organised in Kalpakkam during April 18-23, 1971 for senior personnel from all DAE units who have significant responsibility for, or are associated with organisation planning and project implementation.

There were 57 participants at the Seminar, which was inaugurated by Dr. Vikram Sarabhai. Problems of defining the primary task of organisations and the operating culture, organisation planning and design, management control system and financial management, were some of the subjects discussed.

This seminar is part of the effort designed to ensure the success of DAE's complex projects which depend crucially on effective combination of technical and managerial skills.

The Indian Institute of Management, Ahmedabad assisted the Department in the design of the programme and provided the faculty to conduct the sessions.

NUCLEAR INDIA

is a monthly publication of the Department of Atomic Energy, published around the 20th of each month. To ensure prompt attention, all communications should be addressed to the Editor, NUCLEAR INDIA, Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay 1. While intimating change of address, the code and number given on the wrapper should be mentioned.

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 1, and printed by him at Conway Printers Pvt. Ltd., 163a, Dr. A. B. Road, Worli, Bombay 18.

Registered No. R. N. 9092/62

NUCLEAR INDIA

VOL. 9. NO. 11 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY JULY 1971

High Altitude Research in the Himalayas

NESTLING amidst tall pines and other deciduous trees is the holiday resort of Gulmarg in Kashmir. Because of its location at 2,700 metres and its position at the extreme northern latitude of India, and some special environmental conditions, Gulmarg is also an important centre for high altitude research in the country. A High Altitude Research Laboratory was set up here by the Department of Atomic Energy in 1963 to provide facilities to universities and other institutions. Gulmarg is particularly suitable for conducting research in the areas of cosmic rays, geophysics and solar physics.

The Laboratory is equipped with some advanced facilities including a cosmic-ray neutron monitor which detects more than a quarter of a million counts per hour and provides information about the energy of each of these particles.

Recording Nuclear Blasts

An interesting piece of work going on now at the Laboratory is the continuous recording of very small amplitude atmospheric pressure waves. The magnitude of these pressure waves is one millionth of one atmospheric pressure. The waves are intimately connected with weather conditions and even related to events taking place on the surface of the Sun. The sensitive microbarograph recording these waves is also capable of recording shock waves emanating from nuclear blasts within a distance of a few thousand kilometres. Another experiment presently being conducted is the study of radio waves emitted by certain stars and galaxies.

Yet another experiment is concerned with the study of the concentration of an isotope of silicon (of atomic weight 32) in the waters of the Kashmir Valley. This study was conducted last year by the Tata Institute of Fundamental Research, Bombay, and forms one aspect of its project for determining the age of waters in glaciers, lakes, rivers and wells in India.

The Laboratory has also been conducting studies for the last two years on the Night Airglow — the light produced at some stages in the several photo-chemical reactions occurring in the upper atmospheric constituents such as oxygen, nitrogen, ozone, nitrogen oxide, etc. This light forms about 30 per cent of the light on a moonless night, and its study could lead to an understanding of the chemistry of the upper atmosphere and some aspects of solar-terrestrial relationship.

A study of "Geomagnetic Whistlers" is being conducted at the Laboratory by the Banaras University. The phenomenon results from the propagation of radio waves, generated by a lightening discharge, along the lines of force of the earth's magnetic field

(Continued on page 7)

India's Second Nuclear Power Station



THE RAJASTHAN ATOMIC POWER STATION at Rana Pratap Sagar near Kota, being built with Canadian assistance. The Station will have two units of 200 MWe each. The first unit is expected to be commissioned by the beginning of 1972 while the second will be completed by the end of 1974.

Inside

Solid State Track Detectors in Nuclear Research

Chairman's Report

Electronics Corporation of India Limited

YOUR company was registered in April, 1967. The Company commenced its operations at Hyderabad in October, 1967. The financial year 1970-71 therefore represents the third full year of its operations. I am happy that your company has been able to earn a profit of Rs. 13 lakhs during the year, with a turnover of Rs. 183 lakhs after setting aside Rs. 25 lakhs for depreciation and Rs. 10 lakhs for interest. The profit figure is in no way extraordinary but it assumes significance in the light of present-day complaints that the Public Sector has failed to earn adequate return on investment.

The success of your company is all the more creditable when it is realised that the aim in indigenous development of electronic systems, instruments and components was to make the country's nuclear programme self-reliant. Having developed the above products at the Bhabha Atomic Research Centre, a bold decision was taken to set up your company, based entirely on Indian technology. At the time it was taken, the decision was bold indeed, for not many organisations had dared to undertake production of sophisticated items based entirely on Indian know-how. It has now been conceded that the reason why our national laboratories have had difficulties in transferring their process know-how to our industries, is the gap between a process know-how and industrial production *i.e.*, production engineering. Your company has successfully bridged the gap as is evident from the consistent



Dr. Vikram A. Sarabhai

quality of its products. The success is noteworthy considering that half of your company's products face competition from private sector companies with foreign collaborations.

The story is not one of success all the way. Strict inventory control has yet to be introduced. The company's marketing needs further dynamism. The company is endeavouring to remedy the short falls with the application of modern trends of management.

Among the new products that the company has produced for the first time in this country can be listed the medical scanner, modular transistorised nuclear instruments, geared servo motors and analogue computers. Continuing its development efforts it will add this year the following sophisticated products: 400 channel analysers, ultrasonic flaw detectors, nuclear level gauges, 50 MHz solid state plug-in oscilloscopes, closed circuit television systems, synchros, digital real time computers, microwave test instruments, silicon rectifiers, defence grade tantalum capacitors and metal film resistors. During last year the company completed its supply of control and monitoring instrumentation for the first nuclear reactor at Rajasthan. This year it will supply the requirements for the second unit.

Quantity-wise the company's turnover last year was Rs. 183 lakhs. It expects to increase this to over Rs. 406 lakhs this year. Based on the confidence gathered from the three years' performance in placing Indian technology on a commercial footing, your company has drawn a five year plan to reach an annual turn-over of about Rs. 20 crores in 1975-76. The major expansion will be in the field of computers where Indian effort hitherto was negligible. The company also expects an industrial licence to manufacture commercial TV sets, having already been granted a licence for TV sets for the DAE-NASA Satellite TV experiment. ●

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International Nu

THE fourth meeting of the International Nuclear Data Committee (INDC) of the International Atomic Energy Agency (IAEA) was held during July 12-16, 1971 at the Bhabha Atomic Research Centre, Trombay.

The INDC is an advisory committee to the Director-General, IAEA. It comprises experts from countries having a major programme of developing atomic energy for peaceful purposes. Through this Committee an effort is made to coordinate nuclear data collection work going on in different parts of the world. With such an international effort, duplication of work is avoided and useful information is made available.

India has been a member of the Committee from the very beginning, when it started in 1962 as the International Nuclear Data Scientific Working Group (INDSWG).

The Indian Nuclear Data Group in Trombay, set-up immediately after,

Helping the Body to Accept Grafts

The greatest difficulty in the way of providing spare parts for human beings is still the human body's ability to recognise and attack any foreign material which finds its way into the body. Evolved as a protection against micro-organisms and parasites, this defence system becomes the main limiting factor when the surgical problems involved in transplanting skin, kidneys, livers, hearts, and other organs from newly-dead humans or even from animals have all been solved.

by John Newell

AT present the only commonly used way of getting round the problem is to give doses of immuno-suppressive drugs to patients who have received a foreign organ graft. But the use of these drugs has the serious disadvantage that by damping down the body's defences against foreign tissue it also lowers its defences against infection. Patients who have to be kept on such drugs to prevent them rejecting a grafted organ are, as experience has shown, much more open to dangerous infections than ordinary people. Sometimes they seem more liable to cancer, probably because the body's defence system normally kills off either malignant cells or the viruses which may cause them before they have had time to form tumours.

So although the use of immuno-suppressive drugs can save many lives it is clearly a procedure with serious deficiencies. An alternative approach is to attempt to make the human body accept a foreign graft as though it were a part of the body itself. When this can be done it is called inducing **tolerance** towards the graft. Sometimes, for reasons which are still unknown, if a small amount of tissue of the same type as a grafted organ is injected into an animal before the organ is grafted into the same animal, then this leads to tolerance towards the organ. Although the technique has been little used so far, surgeons are hopeful that eventually they may be able to use similar techniques to make patients tolerate grafted organs without the need for immuno-suppressive drugs.

However, if this technique is to be used on a large scale then it will be necessary first to discover how tolerance can be reliably induced and so far this has proved impossible since no one has really known how tolerance works. A new theory put forward in March by Dr. Anthony Allison of the Clinical Research Centre in Harrow, England together with American scientists of Washington University, has the double attraction of explaining the phenomenon of tolerance in much simpler terms than hitherto and also suggesting how tolerance can be induced to prevent or reduce the need for immuno-suppressive drugs after transplant operations. And there is already a good deal of evidence to support Dr. Allison's theory.

The basis of the theory is that tolerance really comes about not because the body fails to react to the graft but because it reacts to it more strongly than usual. This apparent paradox requires further elucidation. On Dr. Allison's theory the body's defensive reaction against foreign material falls into two parts. First, comes the formation of antibodies, molecules specially designed to attach themselves to the foreigner chemically. Normally the function of the antibodies would be to neutralise harmful toxins. In the second part of the reaction the foreign material is attacked and literally devoured by the scavenging white cells of the blood, the macrophages. Dr. Allison's belief however is that if the first part of the

(Continued on page 8)

Data Committee Meets at BARC

is responsible for maintaining liaison with the INDC, preparing progress reports on nuclear data activities in India, contributing information to the CINDA (Computer Index Neutron Data) and the DASTAR (Data Storage and Retrieval System), and stimulating interest in nuclear data activity.

Through the INDC and the Nuclear Data Section of the Division of Research and Laboratories of the IAEA, Indian scientists receive CINDA manuals, progress reports of other laboratories, unevaluated and evaluated data and other useful information. These benefits will increase when the scope of the INDC becomes wider with the inclusion of programmes such as procurement of targets and samples required for nuclear data measurements.

Shri H. N. Sethna, Director of the Bhabha Atomic Research Centre, who inaugurated the meeting said: "Any country that is interested in a major programme of developing atomic energy for peaceful uses, has necessarily to be interested in nuclear data for these various applications. The Indian atomic energy programme envisages development of fast reactors and fast breeder reactors; a pulsed fast reactor is under construction; a Reactor Research Centre specially devoted to the development of fast breeder reactors is being planned at Kalpakkam near Madras. In view of these developments, measurement, compilation and evaluation of nuclear data is of primary importance to us at this stage. A major facility for nuclear data measurement—a Variable Energy Cyclotron—is under construction at Calcutta."

The Chairman of INDC, G. A. Kolstad and the Scientific Secretary, J. J. Schmidt, also spoke on the occasion.

(Continued on page 8)

SOLID STATE TRACK DETECTO IN NUCLEAR RE

IN 1959, exactly two decades after Hahn and Strassman announced the discovery of nuclear fission, E. C. H. Silk and B. S. Barnes of the Atomic Energy Establishment at Harwell, England, made an almost equally important discovery. While examining mica heavily irradiated with fission fragments they observed linear trails of damage or "tracks" — a revelation which has revolutionised experimental nuclear research in a relatively short time.

Although this finding was made at Harwell, it was left to P. B. Price and his co-workers R. L. Fleischer and R. M. Walker of the General Electric Company of the United States, to recognise its immense potentialities and to develop it from a mere laboratory curiosity into one of the cheapest and most powerful experimental tools in the study of a number of nuclear phenomena. Price and his colleagues initiated their pioneering work in this area in 1961. In less than a decade, the growth of the family of solid-state track detectors, both in size and in applications, has been spectacular. Today, these detectors rank high among research tools in almost all the leading nuclear centres of the world. They are being used in down-to-earth applications like geochronology as also for advanced space-age applications like investigation of heavy and superheavy cosmic particles in outer space and other celestial bodies, (see *Nuclear India*, Vol. 9, No. 8, April 1971). They have also found extensive applications in such diverse fields as biomedical research (*viz.* separating closely-sized cancer cells with precision-made sieves of thin plastic sheets having fission-track holes), environmental research ("bulk-tracing" to study liquid flow or discharged gases into the atmosphere), microanalysis and nuclear technology, to mention a few.

To appreciate the significant role played by this relatively recent discovery in nuclear research, it would be helpful to clear some fundamental questions. What are solid-state track detectors ? What is the most probable mechanism of track formation ? How are they detected and how is the information contained in them decoded into useful data ? What is so unique about them which makes them a top-ranking research tool for work connected with nuclear phenomena ?

More Susceptible

Solid-state track detectors are essentially insulating materials such as mineral crystals (*e.g.* quartz, mica, zircon etc.), glass (*e.g.* pyrex, soda-lime etc.) and plastics (*e.g.* Lexan,* cellulose nitrate, makrofol etc.). Heavy, charged particles passing through such insulating materials knock off electrons from the atoms in the crystal lattice, leaving a number of positive ions which repel one another and violently disturb the lattice structure. These damage trails are more susceptible to chemical attack than the ordinary material and therefore can be subjected to preferential chemical 'etching" which enlarges and "fixes" the damage trails as hollow cylindrical tubes about 50 Å in diameter (1 Å = 10^{-8} cm). Prolonged etching increases the diameter of the cylinders to the micron range (1 micron = 10^{-4} cm) comparable to the wavelength of visible light. These hollow cylinders or "tracks" can then scatter visible light and show up as dark lines when viewed in transmitted light under an ordinary microscope (see the accompanying photomicrographs). In the case of plastics, the charged particles bring about chain rupture as a result of ionization and excitation of the molecules. The chain ends form new species which are chemically highly reactive.

Not all classes of detectors can register all kinds of charged particles. Each track-detector is characterised by a critical value of energy loss rate, (dE/dX) critical, expressed in MeV mg^{-1} cm^{-2} which is a measure of the rate at which the ionising particle deposits its energy per unit distance in the medium. Those which give up energy in excess of the critical value register tracks with unit efficiency, while those which deposit less energy than the critical value do not produce etchable tracks. Fission fragments, being massive and highly energetic, give up energy at a very fast rate and give well-defined tracks in almost all the types of detectors.

by R. H. Iyer
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Track etching

"Developing" or etching the tracks in a given substance depends on a variety of conditions such as the nature of the etching chemical, its concentration, the temperature, as also presence of trace impurities etc. The underlying principle however is that the particle trails, being of a disordered structure, are associated with large free energy and are therefore preferentially attacked. With some experimentation, conditions can be matched to obtain excellent tracks. As in development of photoprints, there is as much art in track-etching as science. The present state of the art

* Trade mark of the General Electric Company, U.S.A. Chemically, Lexan is 4.4' dihydroxy phenyl 2, 2 propane poly-carbonate.

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of track-etching is such that conditions for obtaining excellent tracks for most of the detector materials are known. Unlike the photo-developing process, track-developing requires only the commonest and cheapest of chemicals. For example, tracks in mica and Lexan, two of the most widely used track-detectors, are revealed by etching in concentrated hydrofluoric acid at room temperature and in 6M sodium hydroxide solution at 60°C respectively for about an hour each.

Track counting

Once the tracks are developed, it now remains to determine the actual number of them. The most common method of course is the traditional one of visually observing them in an ordinary microscope in transmitted light under a magnification of about 100-500X. Several other auxiliary methods

(Continued on page 6)





Photomicrographs of fission tracks in Lexan, Figure above shows randomly distributed tracks when the detector is in contact with the fissile material. Figure at right shows tracks photographed at a magnification (750X) to bring out their cylindrical nature. Figure on p. 7 top is a photograph of the recoil chamber with the five perspex cylinders inside. The fissionable target sits at the bottom of the cylinder and the detector is held by pressure inside the perspex cylinders. The fission fragments are all emitted in one direction and are caught in the detector and appear as shown in Figure on p. 7 bottom which shows oriented tracks from the fission of plutonium-239.

Solid State Track Detectors

(Continued from page 6)

of semiautomatic and mechanical track counting systems are also being developed. In one method which is useful for low track densities, an opaque coating of aluminium is made on one side of a thin plastic sheet — thin compared to the length of the tracks in it — and, after exposure to charged particles, the sheet is etched in sodium hydroxide from the uncoated side. Wherever there are tracks, the hydroxide solution attacks and reaches the aluminium coating and eats it up leaving a visible circular hole. The number of such holes can be counted with the naked eye in some cases. In another similar method, the thin plastic, after irradiation, is passed between two electrodes kept at a sparking potential; wherever there is a hole (caused by a track), there will be a discharge between the electrodes which can either be recorded electronically or can be counted visibly as a permanent larger hole caused by the localised burning away of the plastic during the electrical discharge.

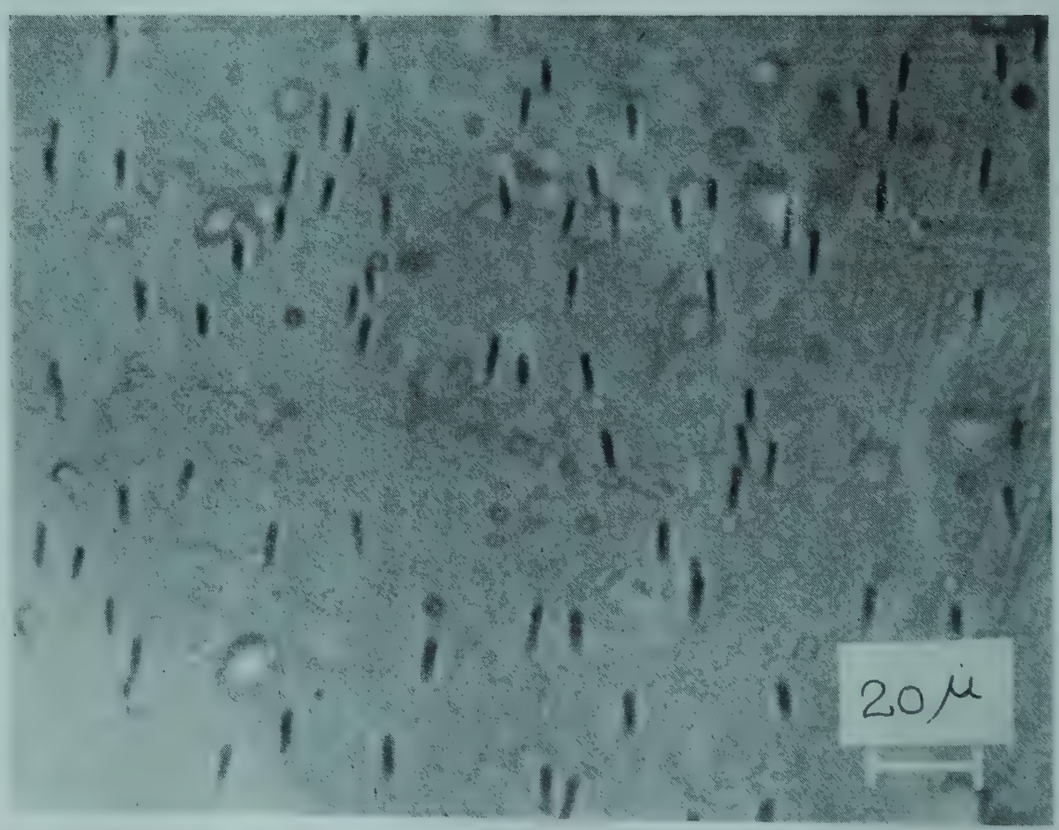
A more recent and by far the most sophisticated automatic track counting system has been reported by D. Jowitt of the Atomic Energy Establishment, Winfrith at Dorset in England (*Nuclear Instruments and Methods*, March 1971). Use is made of a television image analyser 'Quantimet' in conjunction with a scaler and a printer. The microscopic images of the tracks are focussed on to the television camera and the video signals are processed to selected features to be counted on the basis of their optical density and size.

It may be emphasised that all these automatic or semiautomatic track counting systems, while they permit more rapid counting, cannot match the visual scanning in pattern recognition and discrimination.

Striking Advantage

Visual counting of tracks using a microscope though somewhat time-consuming is one of the most reliable





methods of track counting at the present time. In almost all the experiments, the track densities (number of tracks per unit area) or the total number of tracks are determined, from which various other related quantities dictated by the particular experiment are obtained.

Let us examine some of the advantages of this technique in comparison with other well-established but more conventional tools specifically for studies in fission and related processes. Perhaps its most striking advantage over conventional semi-conductor counter (requiring massive support of costly electronics) or the time-consuming radiochemical methods of fission studies, is its simplicity. Once the fission tracks are recorded on the detector, the information is stored and preserved indefinately. Any one can scan the events any time after the experiment, even after several years; there is no radioactive decay and no electronics breakdown to worry about: In fact it is estimated from track fading kinetics studies that tracks formed in zircon can be preserved for an 10^{39} years at normal temperatures and pressures. This property comes in handy in the dating of terrestrial and extra-terrestrial materials *i.e.* in geo- and cosmochronology.

A second advantage is selectivity. The detector can effectively discriminate against processes other than fission (the fission fragment tracks stand out among the barely visible dots due to the fission-inducing particles and other spallation products) and thus affords an opportunity for studying fission events in an essentially "background free" situation. This selectivity has been greatly exploited for the detection of extremely rare fission events. Using glass detectors for example, Russian physicists at the Joint Institute for Nuclear Research at Dubna detected about two spontaneous fission tracks per day of a 0.3 second isotope of the element Kurchatovium (Z = 104) produced by irradiating plutonium with neon ions. But for the use of the glass track detector, the detection of this man-made element would have been an impossibility considering the enormous background radiations associated with the hundreds of hours of accelerator operation required in the experiment. Again, scientists at the Lawrence Radiation Laboratory, USA, using a mica track-detector, determined the fission barrier of ^{201}TI (compound nucleus formed by irradiating ^{197}Au with He^4 ion) by measuring fission cross-sections extending over ten orders of magnitude: The lowest cross section measured was about 3 x $10^{-35} cm^2$ — almost twenty trillion times smaller than the thermal neutron fission cross-section of ^{235}U requiring over 40 hours of bombardment. The intense background associated with long irradiation had no effect on the detector. Solid state track detectors are destined to play an important role in the search for one of man's most sought-after goals in recent times: the discovery of possible man-made super-heavy elements.

Another unique feature of these detectors is sensitivity. It is possible to have a fissile element target-detector assembly with a 2 or 4 geometry allowing every fission event to be recorded. This has made possible determination of uranium concentrations as low as 10^{-14}-10^{-12} atom percent in certain uranium-bearing materials like quartz, mica etc. by reactor neutron irradiation with fluxes that are commonly available.

Work at BARC

A modest programme of work on measurements of fission cross-sections, excitation functions, angular distribution of fission fragments, estimation of fissile isotopes, particularly ^{235}U, neutron flux measurements etc. using the solid-state track detector Lexan has been initiated in the Radiochemistry Division of the Bhabha Atomic Research Centre.

Lexan is least contaminated with heavy elements and can be used for detecting very minute quantities of fissile materials as well as for measuring extremely low cross-sections. Using a single stack of several fissile isotopes in contact with the detector in a 2 geometry and using only microgram amounts of fissile isotopes, it has been possible to measure accurate fast-neutron fission cross sections for the most common isotopes of all the heavy elements — from ^{232}Th to ^{241}Am — in a single experiment in a short time. Similarly, using a novel fission recoil chamber (about the size of a grape fruit) evolved from considerations of neutron economy, it has been possible to measure simultaneously the angular distributions of fast neutron-induced (14 MeV) fission fragments from five independently fissioning nuclei at a time. Flexible Lexan strips held by mere pressure-fit inside 5 perspex cylinders within the recoil chamber made this arrangement possible. A slight modification in the design of the recoil chamber would allow simultaneous measurement of angular distributions for five different neutron energies at a time for a given target. Experiments are also under way to exploit this technique for the estimation of fissile materials, particularly estimation of ^{235}U content of uranium samples, which incidentally, adds a practical flavour to this particular scientific effort in Trombay. ●

High Altitude Research

(Continued from page 1)

back and forth between the high latitude regions of the two hemispheres. This to and fro motion continues till the radio waves become quite weak. These waves are heard on the radio as a series of "whistles", the repetition time of the whistles being equal to the to and fro travel time of the wave.

The Laboratory is also measuring Solar Radiation with equipment set up by the India Meteorological Department. The heat radiation from the Sun is measured at different places and its absorption and reflection by various types of the earth's surface is examined.

A few experiments on aerosols and condensation nuclei have been recently carried out by the India Meteorological Department. These investigations have provided useful information on size, distribution, chemical composition of the aerosols, their dependence on meteorological factors as well as their role in cloud formation. ●

Helping the Body to Accept Grafts

(Continued from page 3)

reaction, the formation of the antibodies, is sufficiently strong, then the second part will never take place. The reason is that if a sufficient quantity of antibodies is produced then these will quite literally camouflage a grafted organ. The antibodies will attach themselves chemically to every part of the organ which is recognisably foreign to the body it has been placed in. And this will mean that there is no way in which the macrophages can recognise the graft as foreign. Therefore, so long as the graft remains covered in a sort of cloak of invisibility, a smoke-screen of antibodies, it will never be attacked and destroyed.

As Dr. Allison is the first to say, much research remains to be done before the idea can be used on a large scale to help grafts to survive. For example, while some antibodies are harmless in themselves, others can damage their graft. Nonetheless one British surgeon has already had some success—first with animals and later with human patients—in promoting the survival of kidney grafts, using very low levels of immuno-suppressive drugs, by actually intensifying the antibody-type reaction against the grafted kidney.

The method used to intensify the reaction was as follows. The patients were children who received kidney transplants from parents. First the surgeon took some blood from one parent of a child in need of a kidney transplant and injected this blood into the other parent. This made the body of the second parent produce antibodies to the tissues of the first parent, as a natural reaction to the foreign tissue in the injected blood. Then the surgeon gave the child a kidney from the body of the first parent together with blood serum containing these antibodies from the second parent. This meant that right from the start the child's bloodstream had antibodies against tissue of the transplanted kidney's type circulating in it, as supplied from the second parent. The effect of the extra antibodies—as animal experiments had already shown would be the case—was to make the child's body manufacture even more antibodies of its own against the kidney than would normally be the case. But the effect of all the antibodies was not to destroy the kidney but to camouflage every single chemical feature of its surface which might have allowed the child's white blood cells to recognise it as foreign—in fact it was protected by the antibodies from destruction.

These ideas have so far only been tried in a few kidney transplants, although the results have been encouraging. But the idea has attractive features in theory as well as practice. Previously doctors had to find some way of explaining why repeated injections of foreign tissue sometimes made humans or animals react to it less rather than more. On the new theory this acquired tolerance is explained simply as a consequence of one part of the reaction being more violent than usual. This simplification certainly makes the idea enticing to theoretical biologists. *(SPECTRUM No. 86, 1971)* ●

Data Group Meet

(Continued from page 3)

Conference on Neutron Induced Fission

A one-day conference on "Neutron Induced Fission" was held as part of the International Nuclear Data Committee meeting. About 120 scientists from the Bhabha Atomic Research Centre, the Tata Institute of Fundamental Research, the Saha Institute of Nuclear Physics and some other research centres in India, and foreign delegates to the meeting, participated. Some of the topics covered are : excitation energy dependence of shell effects in nuclear fission, mass distribution in fission and related phenomena, distribution of total fission width, and prompt neutron and gamma rays from fission. The Conference brought out the point that Nuclear Fission studies are important not only for investigating certain areas of nuclear physics, but also for a proper and careful evaluation of the nuclear data needed for nuclear energy applications. ●

Training Course in Food Irradiation Technology

An International Training Course on 'Food Irradiation Technology and Techniques', sponsored by the International Atomic Energy Agency, Food and Agriculture Organization and the Department of Atomic Energy is being held at Bhabha Atomic Research Centre during November 1-December 10, 1971. Two similar courses were arranged earlier by the Agency at the Massachusetts Institute of Technology, Cambridge (Mass.) in 1967 and at the Michigan State University, East Lansing (Mich.) in 1969. Twenty-two participants from abroad (Brazil, Bulgaria, Chile, Czechoslovakia, Ecuador, Greece, Guatemala, Hungary, Indonesia, Iran, Iraq, Korea, Mexico, Peru, Phillippines, Syria, Taiwan, Thailand, U.A.R. and Uruguay) and six from India will be attending the Course. Lecturers for the Course will include experts from abroad assigned by the Agency, besides senior scientists from BARC. The Course will comprise of lectures and laboratory exercises covering a wide range of topics, including design of irradiators, dosimetry, nutritional, microbiological, entomological, wholesomeness and regulatory aspects of radiation processed foods, besides engineering, technological and economic considerations.

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 1, and printed by him at Conway Printers Pvt. Ltd., 167c, Dr. A. B. Road, Worli, Bombay 18.

Registered No. R. N. 9002/62

NUCLEAR INDIA

VOL. 10. No. 2 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY OCTOBER 1971

Sriharikota Range Starts Functioning

THE Sriharikota Rocket Range (SHAR) on the east coast was the scene of a series of rocket tests in early October. The range is being developed for satellite launchings in the near future. Work on the satellite launch vehicle and other related areas is being done at the Space Science and Technology Centre (SSTC) at Veli Hill, Thumba.

The SHAR range started functioning with the launching of a Rohini RH-125 standard rocket at 11.15 a.m. on 9th October. It carried a dummy payload weighing 4 kg. The objective of this first launch was to test the launching system set up at SHAR. This was

See also pages 4 & 5

followed by the launching of two Rohini RH-125 rockets on October 10. Both the rockets carried technological payloads of 15.6 kg each. The total weight of each vehicle, including the payload, was 40 kg.

Onboard Control

The objective of the launchings on the second day was to evaluate under flight conditions the roll control system of the rockets. This is part of the thrust vector control system being developed by the Control, Guidance and Instrumentation Division of SSTC for use in the proposed satellite launch vehicle. The roll control system consists of a rate gyroscope acting as a roll rate sensor, a pneumatic package, a reaction jet package with two pairs of nozzles to produce the roll correcting forces in either direction, and the associated control electronics.

The output of the rate gyroscope was electronically integrated and telemetered to the ground. The reaction jet package was powered by nitrogen gas

(Continued on page 5)

"Towards the East"



Rohini RH-125 rocket with TVC roll control payload poised for take off at Sriharikota.

Nuclear Power and the Environment

ONE of the factors that is expected to weigh heavily in favour of the eventual introduction of nuclear power stations in Australia is the advantages they have in lessening the problems of pollution associated with power stations using fossil fuels such as coal.

The Australian Atomic Energy Commission, in its recently published annual report for the 1970-71 financial year, pays some attention to the environmental value of nuclear power generation.

The Commission carried out an extensive programme of environmental studies in its preparations for the construction of Australia's first nuclear power station at Jervis Bay in the State of New South Wales.

Planning for the power station, including the assessment of tenders, had reached an advanced stage when the Australian Government decided in June to defer a decision on the power station for a further 12 months for financial reasons.

World Energy Demand

The Commission's report summarises the history of the 500 megawatt project, including some of the research work associated with it.

In a chapter dealing with the environment, the report says that because of population growth and the urge to raise living standards and to expand industry and technology, the demand for energy in industrial countries is doubling every eight to 14 years.

"Extrapolation of the present trend to the end of the century can produce some startling results, such as the possible increase in total world energy demand from about 1,000,000 megawatts in 1970 to 7,000,000 megawatts in 2,000," says the report.

"In 1968, the power generating industry in the United States alone discharged 24,400,000 tons of oxides of sulphur, 10,000,000 tons of oxides of nitrogen and 8,900,000 tons of particulate matter into the atmosphere, together with many other air-borne pollutants.

"If its further energy needs were to be met entirely by burning coal, the United States would need to mine and transport 10,000,000 tons of coal each day by the year 2,000.

"Emissions of sulphur and nitrogen oxides could rise to 122,000,000 tons and 50,000,000 tons per annum respectively as a consequence. A similar situation is developing in Australia, although such detailed figures are not available."

Effect on Climate

The report says that carbon dioxide is not normally considered a pollutant, but concern is growing over the continued emission of this gas and its possible effect on the world's climate.

Since the beginning of the century the average concentration of carbon dioxide in the atmosphere has increased by eight per cent and the present rate of addition (6000 million tons a year) is increasing at approximately the same rate as the demand for energy.

"Environmental disturbances caused by pollution are becoming matters of grave public concern, and it is clear that the community is demanding a radical approach to this problem," says the report.

"Reduction of the pollution and environmental hazard caused by the effluents of coal and oil burning is technically possible in many cases (to a limited extent) but it involves considerable effort, expense and consumption of still more energy. This is a vicious circle which requires to be broken."

Limited Resources

The report says that the world's resources of fossil fuel also are limited and irreplaceable and in the near future may be regarded as invaluable chemical raw materials.

"Nuclear energy offers a solution to many of these problems. It is a clean source of energy which results in no emission of carbon dioxide, sulphur dioxide, oxides of nitrogen, toxic hydrocarbons or fly ash.

"With proper regulation nuclear power stations present no hazard to the environment or to human health.

"They are not expected to displace coal and oil burning stations, but rather to offer a complementary source of energy production. By the end of the century, nuclear power may well be supplying half the world's needs, the remainder coming from coal, oil, natural gas and hydropower."

The report discusses the methods available for the safe handling of radioactive by-products produced by nuclear power generation. It says that the nuclear industry has been policed from its inception and all its waste products have been checked and disposed of under formal approval.

Low-level radioactive discharges are permitted to be released into the environment only at levels that comply with national and international health standards. *(News and Information Bureau, Australia)* ●

Startup of Pickering Unit 2

The second unit of the Pickering nuclear power generating station near Toronto, Canada was started-up on September 15. The reactor is scheduled for full power operation in early 1972. The Pickering station has four 500 MWe CANDU type reactors. Unit 1 reached full power on May 30, 1971, and units 3 and 4 are scheduled for completion in 1972 and 1973. ●

Night Airglow Studies at PRL Ahmedabad

THE Physical Research Laboratory is involved in studies relating to the various interactions taking place between the earth's atmosphere and the electromagnetic and particle radiations from the Sun. The consequence of one such interaction is the emission of light by the sky during night time, the phenomenon known to scientists as the "Night Airglow". Although the absence of sunlight precludes any direct solar influence, the night glow phenomenon

by Dr. P. V. Kulkarni,
Physical Research Laboratory, Ahmedabad

originates during the daylight hours and persists throughout the night. This comes about when solar energy stored in dissociated, ionised, and excited species of atoms and molecules in the upper atmosphere during the day is released at night through various relaxation processes *i.e.*, neutral and ionic recombination, quantum emission, etc.

The night radiations are emitted from the reactions occurring at the different discrete layers of the upper atmosphere ranging from 50 km. to 300 km. or more. Red light of wavelengths of 6300AU and 6364AU and green light of wavelength 5577AU are emitted by excited metastable oxygen atoms. These form the bulk of the night airglow which is about 400 Rayleighs*. Yellow light of 5893 AU wavelength is emitted by sodium atoms. Near infra-red light of wavelength 6800 AU to 40,000 AU emitted by the hydroxyl radical, probably in the 50 — 90 km. layer is also prominent in the night sky.

Mt. Abu Observations

During the past few years intensive work with modern instruments has been going on at the Laboratory and studies made at Mt. Abu in Rajasthan and Gulmarg in Kashmir. These investigations have revealed that X-ray stars have a significant influence on the intensity of some night airglow emissions.

The observations at Mt. Abu during the clear non-moonlit nights from October to March, have shown that an enhanced emission of night airglow occurs at the time of transit of the X-ray source Taurus X-1, in the Crab Nebula. A scanning photometer fabricated at the Physical Research Laboratory has been used to scan the night sky and thereby measure the intensity of the airglow from the different parts of the night sky, two or three times every hour. These measurements have shown that the area of the sky from which the maximum emission occurs shifts in the sky during the course of each night. This shift is in correspondence with the course of the X-ray source. The other X-ray stars appear on the night sky during the monsoon months, when the night skies are generally clouded. Consequently, it has not been possible to extend the studies with respect to those X-ray stars.

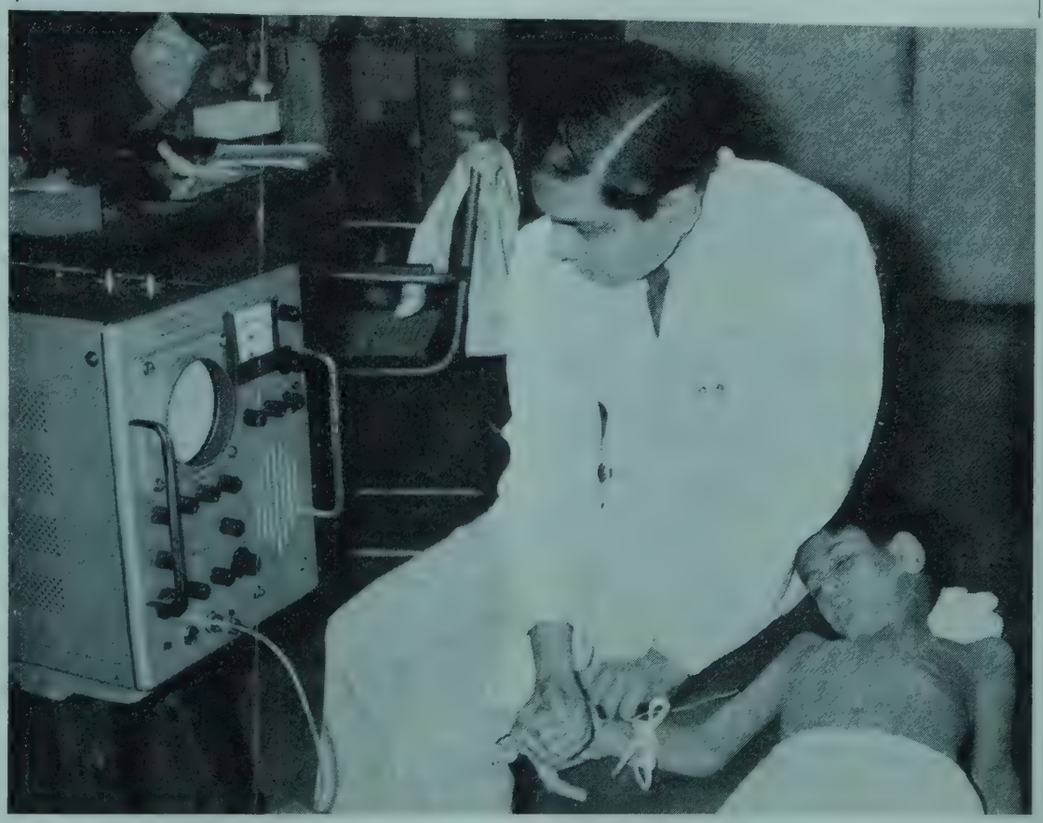
X-Ray Flares

On a few occasions there have been flares on the sun's disc which result in an abundance of X-rays. These are called solar X-ray flares. Some of them occur at local evenings. Airglow measurements carried out by the Physical Research Laboratory on the nights

(Continued on page 5)

* The Rayleigh is the unit of measurement of low intensity brightness. It corresponds to the emission of 10^9 photons per square cm over 4π steradians.

A BARC - Developed EMG



TRANSISTORIZED ELECTROMYOGRAPH: A neurosurgeon at K. E. M. Hospital, Bombay, operates a transistorized electromyograph fabricated at the Bhabha Atomic Research Centre, Trombay. The EMG has been found useful in clinical myography for diagnosing myopathic and neuropathic disorders such as leprosy, muscular dysthrophy etc. as also in rehabilitation myography for treating patients suffering from poliomyelities, paralysis and other neuromusclar diseases.

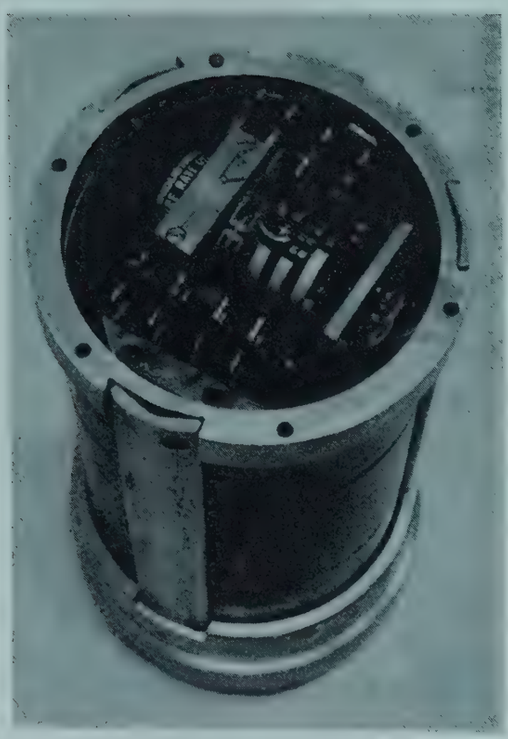
The unit is suitable for use not only with surface electrodes but also with needle electrodes because of its very high input impedance (of the order of 200 megohm) and minimising of cable capacitance effect on the measurements. The sensitivity of the EMG is 30 μ V/cm. It has a built in sweep generator of 10 msec/cm—1 msec/cm sweep speeds, stimulator of 0—200V amplitude, duration of 1 msec and repetition rate of 1 stimulus per sec.

This model of the EMG is the result of joint efforts of engineers of the Electronics Division, BARC and neurosurgeons of Bombay.

The EMG shown above has 95 per cent indigenously-made components.







Top left. *Reaction jet package of Rohini RH-125.*

Above. *Total control package and telemetry being prepared for pre-flight vibration checks.*

Left. *Rate gyro package.*

Facing page. *Take-off of the first roll control flight in India.*

Launchings from Sriharikota



(Continued from page 1)

stored at 100 kg/cm² pressure in a specially designed bottle. The reaction jets were operated on command from the onboard control electronics. The onboard telemetry package consisted of ¼W transmitter at 240.2 MHZ, a pair of aerials and signal processing units. Ground support included an FM/FM telemetry station and a tone ranging system with antennae, all developed at the Thumba Equatorial Rocket Launching Station and installed at SHAR. The performance of the rockets and payloads was satisfactory and the ground stations received good signals from take-off upto splash. The flight time was seventy to ninety seconds and the peak altitude reached was eleven-and-a-half kilometres.

The system developed as payload is part of a complete control system slated for development for larger rocket vehicles. ●

"Pin-point" Launching

A "pin-point" launch by a Skylark sounding rocket was made from Woomera Range, in South Australia, on October 24, seizing a chance which will not occur for another 17 years.

The launch, by a British Aircraft Corporation (BAC) team, was at 12.05 hrs 20 sec. BST. The aim was to measure the position of an X-ray source in space to an accuracy of less than two seconds of arc.

The correct altitude and location had to be achieved to enable observation of the X-ray source — called GX3+1 — at the exact moment it was eclipsed by the moon.

The launch opportunity lasted only one minute — and the next eclipse of the X-ray source over Australia will be in 1988.

A similar launching was made by a BAC team on September 27 when there was also just a one-minute chance.

The experiment was a success, with the result that the first position line to locate the point of GX3+1 could be plotted.

In the second launch (on October 24) it was hoped to achieve the plotting of a second line intersecting the first and giving an even more accurate location of the X-ray source. *(Supplement to "Spectrum" No. 88/71)* ●

Night Airglow

(Continued from p. 3)

immediately following have also indicated a significant increase in the intensity of the hydroxyl emissions.

The production of hydroxyl is attributed to collisions between ozone molecules and hydrogen atoms, whereby oxygen molecules and excited hydroxyl molecules are created. Apparently the presence of X-rays increases the production of H and O atoms and O_3 molecules in the 75-85 km. region. ●

NUCLEAR

INDIA has all the major types of electrical power plants — hydro, coal or oil-fired thermal, and nuclear. Each type has an important role to play in the development of the country. There are however circumstances where nuclear power becomes essential, if inexpensive energy is to be provided.

Hydro power is usually the cheapest. In India the vagaries of the monsoon rains often results in wide fluctuation in the availability of hydel power both seasonally and from year to year. In the years when the rains fail, power cuts in hydro-dominated power grids lead to grave economic consequences.

In a system with limited hydel resources, hydro power is best utilized for peaking purposes, the base load being provided by either conventional thermal or nuclear plants.

Coal deposits in India are concentrated in the Central and Eastern regions. There are thus large areas in the North, West and South which are far away from coal fields. In such regions nuclear power plants with CANDU* reactors of 200 MWe size are competitive with fossil fuel stations at places removed from coal fields by more than 800 kms. Nuclear plants of 500 MWe are expected to be competitive with fossil-fuelled plants in areas much closer. Nuclear power becomes more attractive as the size of the plant becomes larger. Economies of scale are more important in nuclear plants, which have a high initial capital cost but a low operating cost as compared with conventional thermal plants.

The figure opposite shows location of coal fields and the zones within which nuclear power becomes viable owing to high coal costs. India has 4 major regional grids each of which is expected to reach, by 1980, a size of 10,000 MWe, sufficiently large to accommodate a plant of 500 MWe unit capacity.

* of Canadian design, using natural uranium as fuel and heavy water as moderator and coolant.

Benefits of the Nuclear Power Programme

The benefits of nuclear power amount to a very sizeable saving when a country's power programme is viewed in a broad perspective over a period of years. By the year 2000, India will have roughly 43000 MWe of nuclear power, equivalent to about 30 per cent of the total installed capacity. The nuclear stations can all be set up at distances away from coal fields where they would be competitive with conventional thermal stations.

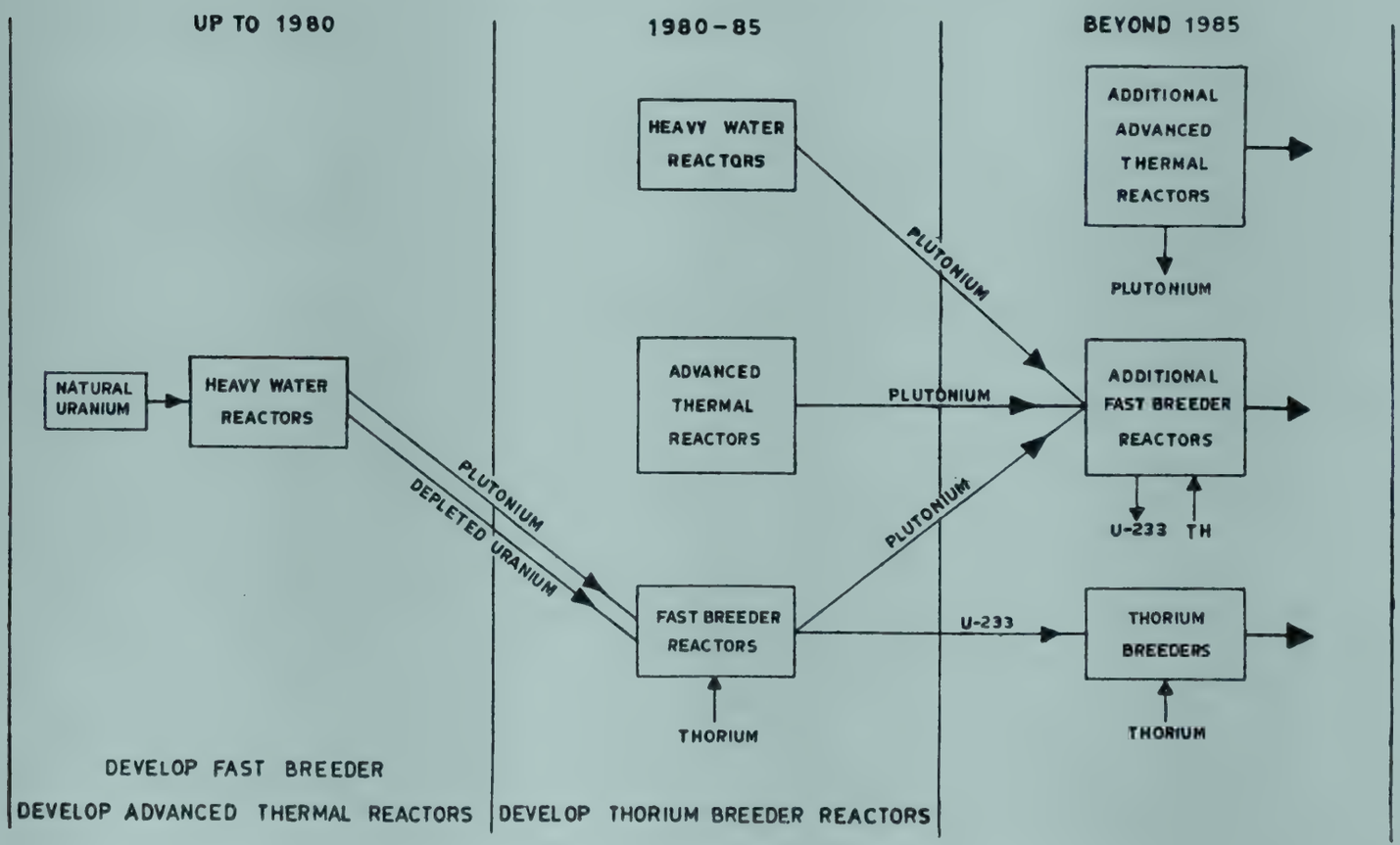
Strategy for Development of Nuclear Power

It the country's nuclear power programme were based solely on natural uranium, the available resources of this fuel would enable it to sustain a total installed capacity of only about 5000 MWe. Thus eventually India has to go in for thorium breeder reactors as it has large resources of thorium.

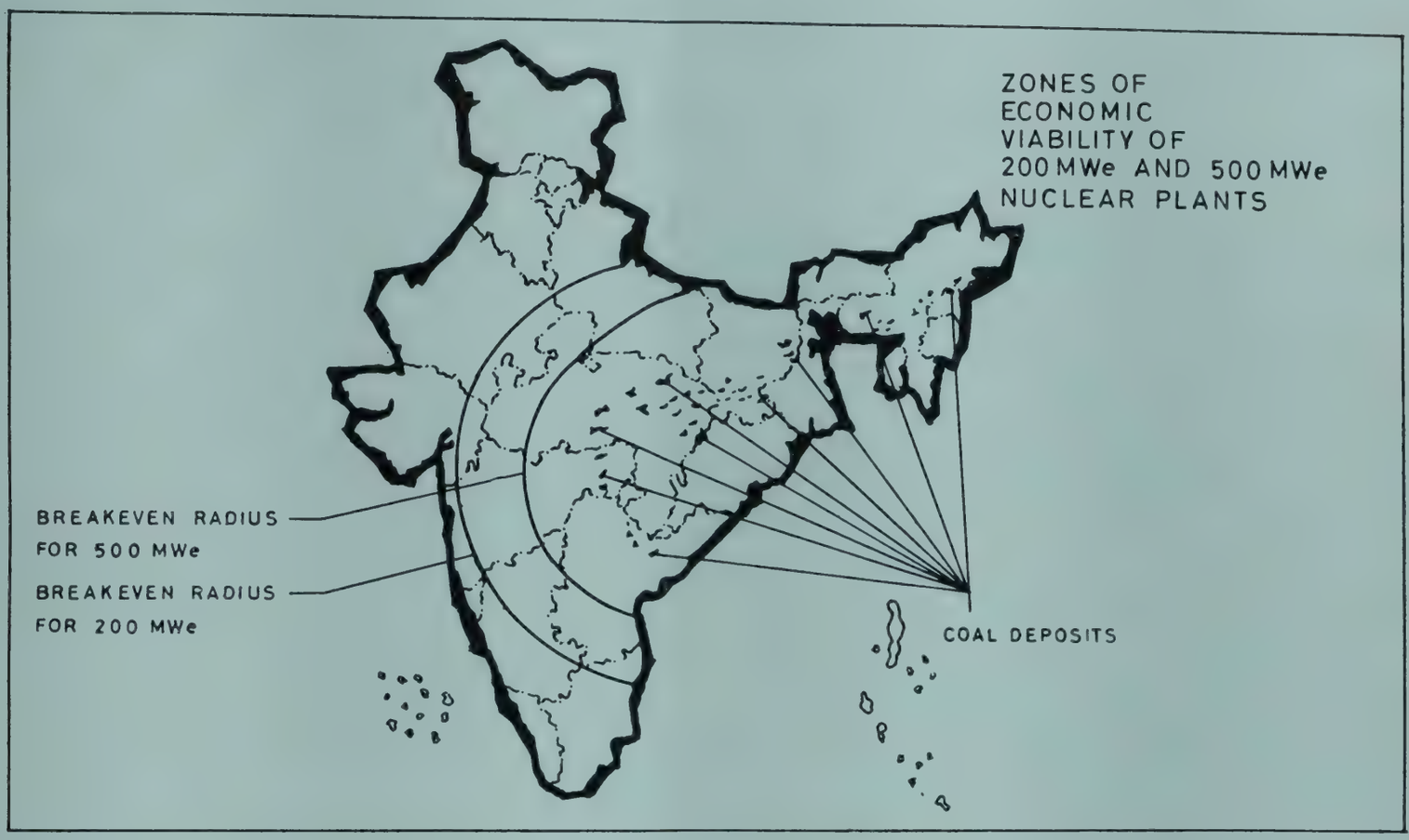
The diagram below explains a strategy which could lead to sustained growth of power, based on nuclear energy, on a self-reliant basis.

As envisioned today, the total installed nuclear power capacity in India will be 2700 MW by 1980, 11,400 MW by 1990 and 43,000 MW by 2000. CANDU design was chosen for the

NUCLEAR POWER STRATEGY IN INDIA



POWER IN INDIA



first stage because it uses natural uranium fuel in the most economic manner.

The research and development work related to the nuclear power programme is being done at the Bhabha Atomic Research Centre at Trombay established as a national centre for R & D in atomic energy in 1957. A Reactor Reseach Centre, being set up at Kalpakkam near the Madras Atomic Power Station, will complement the work of BARC and provide R & D support, particularly in the development of fast reactors and other advanced reactor systems envisaged in the above programme.

Power Plants Built or Under Construction

The first nuclear station to be built is the Tarapur Atomic Power Station, the commissioning of which (in 1969) represents a milestone in India's atomic energy programme. The 400 MWe Tarapur Station has two light water reactors using enriched uranium. It was built by the International General Electric Company of the USA.

Two nuclear power stations are now under construction. Both are of the CANDU types using heavy water as a moderator and coolant, and natural uranium fuel.

The Rajasthan Atomic Power Project at Rana Pratap Sagar in Rajasthan will have 2 units of 200 MWe each. This station is being built with Canadian assistance. The first unit is expected to be commissioned by the beginning of 1972, while the second is expected to be completed by end of 1974.

The Madras Atomic Power Project at Kalpakkam near Madras will also have 2 units of 200 MWe each. This project represents a big advance for Indian nuclear expertise over the other two nuclear power stations in that it is being engineered and built entirely by Indian engineers and scientists. It will have an indigenous content of about 80 per cent. The first unit is expected to be completed by 1975 and the second by 1976.

Support Facilities

The heavy water required for these and future nuclear power stations will be produced by indigenous plants, three of which are being built. These plants, located at Kota in the State of Rajasthan, Baroda in Gujarat State, and Tuticorin in the State of Tamil Nadu are expected to be completed during 1973-75.

Agro-Industrial Complex

The concept of the nuclear powered agro-industrial complex envisages the production of power as cheaply as possible and its utilisation with minimum of additional costs for transmission and distribution. A number of developing nations having small grids are prevented from getting the benefit of the economies of scale of nuclear plants. This handicap can be overcome by setting up consumption centres along with large generating units. Transmission of large blocks of power over long distances is also avoided by having the

(Continued on page 8)

Nuclear Power

(Continued from page 7)

power producing and consuming units close to each other. Detailed economic analysis of such complexes have been carried out for two locations in India — the Indo-Gangetic Plain in U.P. and the Kutch-Saurashtra Region in Western India. Nuclear power is used to produce fertilizers and to pump water for lift irrigation in the case of the Indo-Gangetic Plain study and for desalting sea water in the case of the Kutch-Saurashtra Region study. The table gives the salient features of the Indo-Gangetic Plain study. Although the investments are comparatively high, the returns are also spectacular.

Agro-Industrial Complex in the Indo-Gangetic Plain

Nuclear Power Station	:	2 x 600 MWe
Fertilizers	:	
Nitrogenous	:	372,240 Te of N/annum
Phosphatic	:	206,250 Te of P_2O_5/annum
Aluminium	:	50,000 Te/annum
Tubewells energized	:	
Deep	:	12,860
Shallow	:	12,940
Area Irrigated	:	1.5 Million Hectares
Additional Food Production	:	
Cereals	:	7.80 million Te
Pulses	:	1.66 million Te
Employment Generated	:	1.4 million
Additional GNP	:	$ 1300 million
Investment	:	$ 1800 million
Return on Investment	:	more than 50%

Making Cosmic Rays in the Laboratory

SCIENTISTS at Lawrence Berkeley Laboratory (formerly Lawrence Radiation Laboratory) of the University of California have reported boosting nitrogen nuclei to an energy of 36 GeV in the Lab's Bevatron. This is said to have been the highest energy ever achieved in the acceleration of heavy particles and to have brought a rush of new experiments from scientists at the Laboratory and elsewhere.

"This is a very great achievement. It opens the door to advances in many fields, including biology and medicine, space science, physics, and chemistry," stated Edwin M. McMillan, laboratory director.

An important motivation of the Bevatron heavy particle programme is to extend the research the Lab has done on the use of high energy particles in biology and medicine. For several years, scientists at the Laboratory have been seeking a practical accelerator concept for obtaining heavier high energy particles — such as nitrogen, neon, and argon-which in theory have a greater effect on malignant cells than do any radiations previously available.

New Studies

The nitrogen beam is said to be the closest man has come to duplicating the heavy component of the cosmic rays that are present everywhere outside earth's magnetic shield. The Bevatron's "man-made cosmic rays" will aid in the study of the natural cosmic rays. The heavy ion beams also allow physicists and chemists to make entirely new studies of reactions and forces in complex nuclei, including fission processes.

The Bevatron was designed to accelerate protons, but was modified to accept and accelerate nitrogen beams as the first step of a programme to produce more abundant beams of heavier ions. Future steps in the programme, now under study, involve a proposal to connect the Laboratory's Super-Hilac (heavy ion linear accelerator) to the Bevatron. Such a teaming of the two accelerators would give access to high energy beams of particles as heavy as argon, element 18, with possible beams of krypton, element 36, according to calculations. (*Nuclear News, Oct. 1971*)

NUCLEAR INDIA

is a monthly publication of the Department of Atomic Energy, published around the 20th of each month. To ensure prompt attention, all communications should be addressed to the Editor, NUCLEAR INDIA, Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay 1. While intimating change of address, the code and number given on the wrapper should be mentioned.

XIIth Symposium on Cosmic Rays, Astrophysics and Particle Physics

December 27-31 1971

Venue : Department of Physics, Punjab University, Chandigarh.

Subjects

Primary Cosmic Rays	Moon
Modulation	Meteorites
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Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 1, and printed by him at Conway Printers Pvt. Ltd., 167c, Dr. A. B. Road, Worli, Bombay 18.

Registered No. R. N. 9002/62

NUCLEAR INDIA

VOL. 10. NOs. 3 & 4 A PUBLICATION OF THE DEPARTMENT OF ATOMIC ENERGY NOV./DEC. 1971

Trombay Symposium On Cellular Processes

MOLECULAR control of growth, development and differentiation in plants and animal systems was the subject of discussion at a symposium held at the Bhabha Atomic Research Centre, Trombay, during November 22 — 24. The symposium, on "Cellular Processes in Growth, Development and Differentiation", covered significant areas of biological science in which there is great interest today among classical biologists, biophysicists, biochemists and even some mathematicians, who wish to understand the molecular mechanisms controlling cellular processes.

Growth, development and differentiation are various aspects covering the life-span of a living organism. During

See also page 6

the last 25 years, biologists have been striving to explain at molecular level, *i.e.*, in terms of chemical events, the various physiological functions of living cells. This effort has been amply rewarded and they now hope that a number of cellular processes that lead to growth and development can be explained in these terms.

The symposium was organised by the Biology and Medical Committee of the Department of Atomic Energy. There were 45 participants including five from the United States. Among the U.S. scientists was Prof. Charles Huggins of the University of Chicago who was awarded the Nobel Prize in 1966 for research work on cancer.

Dr. A. Sreenivasan of the Biochemistry and Food Technology Division of the Centre and Shri H. N. Sethna, Director of the Bhabha Atomic Research Centre, addressed the partici-

(Continued on page 7)



A BARC scientist, Dr. Paul Thomas, explains work relating to radiation preservation of bananas to participants of the International Training Course in Irradiation Technology.

Training Course in Irradiation Technology

TWENTY-FIVE scientists and technologists from twenty countries including India spent six weeks from November 1 to December 10, 1971, at the Bhabha Atomic Research Centre's Food Irradiation and Processing Laboratory, at Trombay undergoing an International Training Course in Food Irradiation Technology and Techniques sponsored jointly by the International Atomic Energy Agency, the Food and Agricultural Organization and the Department of Atomic Energy. This was the first course of its kind conducted in India. Two similar courses have been held in the past at the Massachusetts Institute of Technology and the Michigan State University in the United States. Both these courses were sponsored by the joint FAO/IAEA Divisions of food and agriculture.

Welcoming the participants, Dr. A. Sreenivasan of the Biochemistry and Food Technology Division of BARC, who was the Director of the Course, said it was in the fitness of things that India was the host for the course as the scope for utilising the technology for food preservation was greater in the developing areas than in the industrially advanced regions. Reviewing the Division's collaboration with the IAEA and the continuing exchange of experiences is this area, Dr. Sreenivasan acquainted the participants with the status of research work at BARC in this field. He explained that scaling of operations had been concluded on certain processes using low dose irradiation for prevention of food losses through insect disinfestation, control of physiological processes or elimina-

(Continued on page 11)

Evolving Concepts of Growth, Development and Differentiation

by Dr. A. Sreenivasan

Bhabha Atomic Research Centre

Classical to Modern Biology

BIOLOGY today is entering a phase of altogether exceptional growth and advance. This, one may say, is its second such upsurge. The first was the Darwinian era when his concept of evolution by natural selection provided the theoretical framework for an efflorescence of phylogenetic studies and the development of classical Mendelian genetics, completing the edifice he had erected.

During the past two decades or so, we have gained more and deeper insights into the logic and nature of Life. This has been achieved by probing life in the simplest forms in which it could exist. Geneticists have used not only mice and Drosophila, but also bacteria and viruses. Biochemists and biophysicists have gone beyond the study of relatively complex parts of tissues and cells to the basic elementary macro-molecules—proteins and nucleic acids—on which the character of living systems depends. The last few years have witnessed an almost explosive development in molecular biology, mostly from researches with micro-organisms.

Recent Progress in Molecular Biology

Thus, the significant new information we now have on the precise molecular structure of important biological compounds, including proteins, has made possible a direct insight into enzyme actions and other biomolecular interactions. The unravelling of DNA structure and the rapid developments that followed this discovery—elucidation of genetic code, formation of a model for gene regulation and delineation of steps in RNA and protein syntheses—have had an enormous impact on the central concepts of biology. The stupendous achievement of the laboratory assembly of a gene from wholly synthetic blocks has opened up possibilities for manipulations of genetic material that would have been inconceivable only a few years ago. No less remarkable has been the isolation of the *lac* operon from the genome of *Escherichia coli*.

Our knowledge on the mode of transcription, the transfer of information from DNA to RNA, is becoming more complete, thanks to incisive studies on RNA polymerases and factors involved in initiation and termination of RNA chain growth. Work in many laboratories all over the world is leading to ever more precise genetic mapping of RNA bacteriophages and of the mechanisms of transcription in their genomes. Most of the features of replication machinery of Obeta phage have now been elucidated.

A rather striking recent discovery concerns certain RNA viruses and their association with the genesis of some animal tumours. It has been shown that these viruses have enzyme systems that can direct synthesis of DNA on RNA template. This represents a reversal of conventional and more usual flow of genetic information from DNA to RNA to protein — a pattern that had indeed been envisioned in the early 1950's by Dr. Crick in his Central Dogma of Molecular Biology.

Molecular Biology of Growth and Development in Eukaryotes

The framework of present-day molecular biology has provided a vantage point in the investigative trail of the modern biologist who has now begun to concern himself with elucidating the basic processes of growth, development and differentiation. However, the complexities of the eukaryotic cell pose problems that are not encountered with the bacterial cell. While the essential features of the DNA are likely to be the same in all organisms, it is difficult to envisage at present whether the model of gene expression and regulation in microorganisms can be applied to turning on and off of specific genes in multicellular organisms. Detailed information on structure of chromosomes in higher organisms is clearly necessary. Studies on the nature of chromosomal components have been in progress for some years and we know a great deal about histones and other chromosomal proteins. The pace of research in this area at the present time holds promise that a clearer picture of chromosomal structure should emerge in the near future.

The unique occurrence of repeating sequences of DNA in the chromosomes of a wide variety of higher organisms raises searching questions that may have significance in many areas of molecular genetics, developmental biology and evolution. There is reason to believe that the existence of multiple gene copies is apparently of relevance in the control and programming of genetic activity.

Yet another level at which control could be exerted is by modulating RNA polymerase activity. Recent successes in solubilisation and purification of RNA polymerase enzymes from mammalian tissues together with the fund of information already available on bacterial RNA polymerases should uncover as yet unknown aspects of transcription mechanism in eukaryotic cells.

There is hope that eukaryotic cells will now be amenable to molecular biological approaches. The fact that most cells of nearly all higher organisms are diploids had for long placed serious limitations on their genetic

study. The dream of the geneticist to have haploid cell cultures of higher organisms has now been realised. Experimental techniques of great skill have been developed for removing the maternal nuclei from ova of frog which had been penetrated by sperm cells and inducing the operated egg to develop. The fact that mammalian cell hybridisation is now possible has also given rise to high expectations regarding its utility as a tool of great potential in genetic analysis of eukaryotic cells.

Membrane Structure and Function

WITH the wealth of our present knowledge on the ultrastructural organisation within cells and on the assignment of biochemical functions to the sub-cellular organelles, it has been possible to construct fairly precise models of cellular activities and their control under a variety of environmental conditions, although some major lacunae still exist. While the progress in elucidating soluble multi-enzyme systems has been generally very rapid, attempts to resolve and reconstruct structure-bound multi-enzyme systems has been only moderately successful. A new concept which appears to be emerging from the work on mitochondrial membranes is that many, if not all, of the protein components play an important structural as well as a catalytic role. Active researches on the structure-function relationship in mitochondria using sophisticated techniques of freeze-etching, electron microscopy and others. have made possible significant advances in this difficult area.

Our understanding of the synthesis of proteins, though spectacular, has been confined so far to a general elucidation of the biochemical reactions and some of the regulatory aspects. We know very little with respect to synthesis of proteins which are integral components of the cellular network. A beginning has been made recently for studying the topological aspects of cellular protein synthesis, especially the involvement of membranes. Some of our own data, have indicated involvement of the cell membrane in the dimerisation of inactive monomer subunits of alkaline phosphatase into active enzyme. Work in many laboratories is now converging on the nature of proteins formed on free and membrane-bound polysomes. The concept of a stable translating messenger RNA associated with endoplasmic reticulum membrane has been invoked to explain some aspects of the regulation of protein biosynthesis in the eukaryotic cell. This 'membron' concept will need to be upheld by future experimentation. Studies along these lines are in progress at this Research Centre.

One of the problems under intensive study is the biogenesis of supramolecular structures. Although beset with many difficulties, we are much better equipped today both conceptually and technique-wise to be hopeful of getting decisive answers in the not-too-distant future. Already notable advances have been made in the biogenesis of cellular organelles like mitochondria and plastids and evidence will be presented at these meetings to establish the existence of transitional forms during maturation of mitochondria. We have also demonstrated the presence of a soluble lipoprotein in mitochondria which could be a membrane precursor. A good beginning has been made on the molecular basis of membrane generation in the bacterial cell.

Hormonal Regulation

Multicellular organisms are obviously endowed with trigger mechanisms that govern the regulation of cellular processes. Numerous attempts have been made to sort out the switches and the molecular mechanisms they activate. The area of research on the intercellular message systems — the hormones — is both vigorous and complex. Although a great deal is known about the integrating influences of the hormones, our knowledge on the molecular bases of their actions is far from complete. Cortisone and tri-iodothyronine have been shown by us to act through amplification of template activity of chromatin.

The identification of initial site(s) of hormonal action is an essential pre-requisite to building up molecular models explaining the trigger mechanisms underlying their regulation of physiological processes. Attempts to locate receptor molecules have resulted in the discovery of some proteins in cell sap that bind specifically with certain steroid hormones; such complexes seem to enter the nucleus and transfer the hormone to the chromatin.

Adenyl cyclase, the ubiquitous constituent of plasma membrane, is perhaps the closest one has gone towards recognizing a common target of hormone action. A large and ever-growing number of hormones are now known in which either a very rapid response of adenyl cyclase has been shown following hormone administration, or where the many biochemical and physiological actions of the hormones are mimicked by cyclic AMP.

Cyclic AMP has been shown to act by a variety of mechanisms. Its role in glycogen synthesis has been well defined. The precise manner in which cyclic AMP participates in the transcription of the *lac* operon in *Escherichia coli* has also been elegantly elucidated. It will be most interesting to find out whether this nucleotide governs induction of certain enzymes in mammalian tissues in a similar fashion.

The introduction, in the past few years, of tissue and organ culture systems is a promising development for studying mechanism of hormone action. With such a simplified experimental system, it should be possible to distinguish the effect of the hormone in regulating activation or synthesis of specific proteins. It is only in this manner that the effect of any regulator can be analysed in complete isolation from the effect of other humoral factors.

Differentiation and De-differentiation

MAJOR areas of biology now being infused with contemporary molecular genetic thought are those of differentiation and de-differentiation. Studies are being directed to understand systems like spore formation and, already, some very interesting clues are emerging. Biochemical factors influencing sporulation in bacteria and yeast

(Continued on page 9)

ACCIDEN

By P. Abraham, *Health Physics Divis*

Unless a plant is safe, it cannot be efficient. Production is not an end in itself, but is only a means to attain the end. The safety philosophy rests on the premise of the absolute value of human life and no cost is too great for its preservation and safety. The most precious resource that the managements have the duty to protect is their employees. Although safe and healthful working conditions can be justified on a "cold dollar and cent basis", it is preferable to justify them on the basic principle that it is the right thing to do. If safety cannot be afforded, one cannot afford to be in business. The attitude of management should be man-centred rather than productivity-centred. The emphasis should not be on what an accident costs to the employer, but on what it costs to the employee, his family and the community as a whole. The real cost of accidents is measured in terms of human suffering and anguish and the physical and psychological effects, often for many years, of wrecked domestic economics. This is the most painful part of the story. No amount of monetary compensation can restore the divine gift of a healthy body with unimpaired physical fitness. This should provide the main incentive for programmes of accident prevention. Production must — safety first.

ACCIDENTS are caused by inadequate attention of the management towards safety measures, inadequate compliance by workers to safety precautions or both. Optimum production cannot be achieved without adequate safety measures. The same

WE are living in an age of unprecedentedly rapid technological progress. It is often taken for granted that technological progress is a good thing in itself, without regard to its effects on human life. Advance of technology brings in its wake new processes and new hazards. Mankind is now facing a monumental problem in the pollution of the environment, created by uncontrolled technology. Modern factories with their mass production methods, have also brought on tragic accidents involving loss of lives and limbs, either through fault of workers or through negligence on the part of employers or both. The magnitude of the problem can be visualised only when one looks at the staggering figures of fatalities and injuries taking place. About 2,60,000 reportable accidents occur every year in our country, of which 600 are fatal. In Maharashtra alone during 1968, there were 97 fatal, 200 major and 53,000 minor accidents. On a rough estimate, the loss to the nation from these accidents is three crores of rupees per annum. The nation loses 2.5 million man-days as a result of accidents alone. Man has to find ways and means to combat these hazards in order to reap the benefits of technology without injuring himself.

Highest Incidence

Automobile accidents are causing a large number of deaths every year all over the world. It is reported that in the United States alone, 1250 persons get killed every week in highway accidents. More than 44 lakhs of Americans are injured in auto accidents annually. It is estimated that 3933 persons were killed and injured in rail accidents, during 1968-69, in India. Our country has also the dubious distinction of leading the rest of the world in the number of people killed annually in road accidents. The number of road accidents in India during 1965 was about 8 for every 100 vehicles, compared to one for France, West Germany, Britain, Russia and other developed countries. Police officers say that for every citation given, 3000 violations have been committed. We always complain about the one traffic ticket, but we are strangely silent about the 3000 times we escaped. Laws have been broken; penalty must be paid. While driving, remember that the traffic rules are made not to make you late but to prevent you from getting a fast ride in an ambulance and a slow one in a hearse, ahead of time.

An accident is defined as an unplanned, uncontrolled, undesirable event or sudden mishap which interrupts an activity. All accidents do not result in injuries. Depending upon the activity involved, the ratio of accidents producing injuries to those producing no injury varies over a considerable range. Although an injury is not involved, delay in production, damaged material, reduction of quality or additional wear on equipment may be a product of the accident. The need for checking all accidents is, therefore, evident.

Unsafe Conditions

Any unsafe act minimises the degree of safety normally present. However, not every unsafe act produces an accident. Most unsafe conditions have been observed before the accident takes place. Ample opportunities exist to prevent unsafe acts and conditions before an accident occurs. It is estimated that 88% of all accidents result primarily from unsafe acts, 10% from unsafe conditions and 2% from acts of God. Many so-called unsafe acts might turn out to be unsafe conditions. In many cases, we can find that faulty design, inadequate guards, poor working conditions, lack of standardisation etc., have trapped the worker into performing the so-called unsafe act. A close examination would thus reveal that many accidents result from a combination of unsafe acts and conditions. An employee may perform an unsafe act several times without being hurt — but most likely not without costing the employer in terms of slipshod work, damaged material or delays in production. For example, a tool falling from a height and crushing a worker's toe is a dramatic reminder that many tools have fallen earlier without hitting a foot, but nevertheless adding to expense in terms of damaged material, reduced quality and delay.

Some have the notion that efforts to improve safety will interfere with production. This feeling is not true. In fact, maximum productivity is attained only when the accident rate reaches an irreducible minimum.

* *Courtesy: All India Radio.*

'S DO NOT JUST *HAPPEN**

ha Atomic Research Centre

management principles and concepts that are applied to quality, costs and production must be applied to promotion of safety consciousness and prevention of industrial accidents. Every accident interferes with production. The loss of productivity is brought into sharp focus by serious accidents. The minor injury, however, cannot be dismissed as an uncontrollable factor in the production scheme. Whenever an accident occurs, it is an opportunity to study the deficiencies of the safety arrangements and to plan improvements. The circumstances leading to the accident should be examined. Investigation of the minor injury is of considerable importance. It is a matter of chance that the minor injury is not of a more serious consequence. For example, one person may fall from a chair and get up without a scratch, while another less fortunate individual will sustain a broken neck. Considerably more production time is lost every year because of the so called minor injuries than because of disabling injuries. Yet, they do not sometimes receive the attention they deserve. There should be a careful system of reporting all accidents. It is useful to report 'near misses' also.

Real accomplishment in safety brings far more dividends than those detected by casual observation. A safe place to work and a safety conscious management rank high among the things an employee looks for in his job. He resents the lack of consideration for his welfare, his comfort or his safety by his employer. The continuous concern that the employer demonstrates for the safety of his men, is a sensitive indicator for the respect he has for them. Moreover, the employee's family has great concern for his safety, while he is at work.

The expenditure on safety is investment in security and this investment would yield a higher return both in terms of higher production and greater human happiness. Through his safety efforts, the employer helps improve the community relations of his company. A high accident rate in any community would decrease its earning capacity and leave some families in continuous misery. It is, hence, the employer's responsibility as a good neighbour to help reduce accidents on and off the job and thus to contribute to the welfare of the community.

Basic Principle

THE word "accident" is often a convenient excuse. It absolves us from any responsibility as if it happens all by itself. Every accident has a cause. It is widely accepted now that accidents are caused, they do not just happen. Thus finding the cause of accidents, steps can be taken to prevent them. This basic safety principle is relatively simple and easily understood. Apparently, the simplicity of this statement creates doubts in the minds of some. This doubt is evident in the statistics and reports which attempt to associate injuries with accident proneness, psychosis, alcoholism, childhood backgrounds and a multitude of other factors and conditions other than a lack of safety awareness, the safety performance of supervisors, unsafe acts and unsafe conditions. Many are misled to think that safety is a matter for the industrial psychologists or the safety department rather than a matter that the supervisor is better qualified to handle by the accepted methods of good supervision.

Basically what is required for ensuring safety is an acceptance of and a firm belief in the concepts that accidents are caused and that steps are necessary to control accidents and to prevent their recurrence. The problem is to create a safety awareness or to make an indelible impression on the mind of each individual that there is a standard, safe way to carry out all activities. It should be realised that it is not the right way, if it is not safe.

The fundamental safety principles are by no means new. The accident prevention concepts were outlined, in the characteristic 19th century style, as early as October 1880 in the *Atlantic Monthly*. "We might say with perfect legitimacy that a friend of ours, who had slipped on the ice upon his door step and cracked his skull, some months after dining with thirteen at the table, died because of that ominous feast. I know, in fact, one such instance; and I might, if I chose, contend with perfect logical propriety, that the slip on the ice was no real accident. There are no accidents, I might say. The whole history of the world converged to produce that slip. If anything had been left out, the slip would not have occurred just then and there..... If, in the case of the unfortunate man, we lose ourselves in contemplation of the thirteen-at-table mystery and fail to notice the ice on the step and cover it with ashes, some other poor fellow, who had never dined out in his life, may slip on it in coming to the door and fall and break his head too."

Convincing Evidence

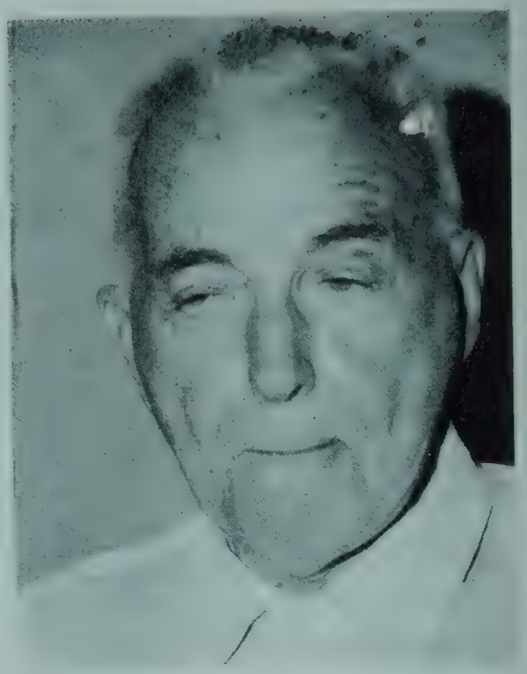
Modern supervisors might not be so disengaged as to lose sight of the cause of an accident in contemplation of the thirteen-at-table mystery, or the inauspicious day from the point of view of superstition. In many cases corrective action has been, however, postponed assuming that the unlucky accident could not happen in another hundred years.

The fact that an accident has occurred is convincing evidence that it

(Continued on page 8)

Interview

Prof. Charles Huggins



Born September 22, 1901 in Halifax, Nova Scotia, Canada, Prof. Huggins got his M.D. from Harvard in 1924. After post-graduate training at the University of Michigan during 1924-27, he was on the staff of the University of Chicago, where later he worked as Professor of Surgery. In 1966 he received the Nobel Prize for Medicine. He is also the Chancellor of Acadia University, U.S.A. today.

Among the distinguished scientists who participated in the Trombay symposium on "Cellular Processes in Growth, Development and Differentiation", during Nov. 22–24, 1971 was Prof. Charles Huggins from the University of Chicago, U.S.A. Prof. Huggins who is the William B. Ogden Distinguished Service Professor at the University, is known for his outstanding research work on cancer-producing substances, for which he received the Nobel Prize in 1966. Prof. Huggins talks here very briefly on his research work and some related questions of the day on cancer to Dr. P. R. Mahadevan of the Biology and Agriculture Division of the Bhabha Atomic Research Centre and the editor.

Prof. Huggins, could you tell us something about your line of research and the work which won you the Nobel Prize?

Well, at present we are involved in determining the causes and cure of cancer. I would specifically say that our work relates to hormone cancer. Hormones are found in the body but the quantity varies and the character and growth of the tumour is dependent on hormones. We found that when one removes some hormones from the body sometimes malignant growth disappears. For example, a man with cancer of prostate, far advanced, who is not able to do anything, can be back to work in 24 hours after removal of the hormones. Four weeks after removal of the hormones, and ten weeks later he will be moving with his family, playing tennis, and engaged in business. This is control by "parched earth."

We believe, like radiation and chemicals, hormones can cause cancer—they are radiomimetic in that sense. However, cancer can also be controlled by giving hormones. This is the work we are engaged in at present, and for the work done by us on hormones in relation to cancer we received the Nobel Prize. Of course a number of things have still to be done.

You have done a good deal of work on inter-relationships between the development of cancer and hormones. Would you comment on how this knowledge can be exploited clinically?

Cancer is rare between the ages of 18 and 35, when there is optimal production of steroid hormones in the body. However it is seen before and after this stage. This indicates the relationship of hormones to cancer. We believe hormones can cure cancer. The day could well come when "a pill (hormone)-a-day-keeps-cancer away" would be the order of the day. Incidentally, I must mention a very interesting thing here. Contraceptive pills have been found to prevent cancer rather than cause it!

Can some forms of human cancers be of viral origin ? If so, do you envisage any measures for control and cure of such cancers?

To a small extent. There is absolutely no way of controlling viral cancer that we can envisage from the present state of knowledge.

About the causes. What do you think of smoking?

I believe smoking is a very important agent that causes cancer. Smoking is related to lung cancer. There is no controversy about this.

Are there any sensitive tests developed to detect cancer at very early stages?

No real tests are available. If we have the facilities, the examination of every person twice each year will be very helpful, but it is not practical.

What forms of cancer are most prevalent in the United States?

Cancer of the prostate, breast, lukaemia, stomach, lung cancer — in that order — are the common types.

In what manner techniques such as tissue culture and organ culture have aided in the elucidation of certain aspects of malignant tarnsformation ?

Yes. Several of these techniques are means of studying interaction between normal cells and cancer cells.

We find that many of the important projects of a fundamental nature in biology in the United States have been supported by funds allotted for cancer research. Could you elaborate on research funding for cancer?

I think in research there are three fundamental components: The head, the hand and the heart. Theoretical aspects in cancer research are important. But we need "hands" and we need the cooperative work of the head and the heart. This means that a lot of work in basic research is needed — by our own hands. They are of fundamental importance and will lead to interesting things. It is not necessary that one be involved directly and specifically in cancer research. I call all biological research, cancer research. Actually these are done from the study of normal tissues. We had a phased programme to put a man on the moon which was built on findings from prior basic research. We decided to have atomic fission and atomic fusion to make atomic bombs and drew on the findings of basic research which was going on. There is not enough known about cancer now to go on to the second stage, that of systematic development of cures. It is still in the discovery stage, we need fundamental research for each development. That is why we need significant funding for this type of basic research.

To what extent recent spectacular achievements in molecular biology — like the elucidation of the genetic code — have had an impact on the current cancer research programme?

The recent developments in molecular biology have been significant. However, the value of molecular biology has not been of utmost importance. For example, molecular biology is concerned with important fundamental aspects of organisms like bacteria and phage. Our body is composed of eukaryotes. The bacteria and phage have one chromosome and we have 46. Nevertheless molecular biology has stimulated and it may be a help in discovering a way to cure cancer in eukaryotes.

Could you tell us how your involvement in the study of the life processes, and the insight gained into these processes has influenced your vision of life?

The work involved is of basic fundamental importance with a lot of philosophical implications. I am like a poet because the work is interesting and creative. The originality of man is depicted in a scientist. In other words excellence in science is like excellence in art.

Prof. Huggins, would you like to say something to young researchers in India?

My advice is: Follow the footsteps of C. V. Raman. Reflect, contemplate and dedicate yourself in defining the problem. I would say to them: "research is fun".

Mystery of Life Processes Continues

(Continued from page 1)

pants. Dr. Sreenivasan, who was Chairman of the Committee, read a paper on "Evolving Concepts of Growth, Development and Differentiation" at the inaugural session. (*See page* 2).

Welcoming the participants, Shri Sethna expressed the non-biologist's awe at the overwhelming revelations and discoveries made by researchers during the last two decades in their effort to understand life processes. In spite of all the advances made so far in the area of molecular biology, Shri Sethna said, there was still a lack of explanation for the various steps in growth, development and differentiation. "We have to expand our knowledge in these areas," he added. The importance of acquiring basic knowledge in this field, he said, is well realized.

Even in the United States where there has been a cut in funds for general scientific research, special funding is made available for cancer research and research work on cell differentiation.

While knowledge is accumulating on morphological, biochemical and functional changes in cells, one still lacks information about the primary steps that lead cells to a state of damage beyond repair. Biologists are also puzzled he said, by the molecular mechanisms that lie behind the storage and retrieval of memory and the loss of such processes during aging. Biology, he said had progressed rapidly during the last few years and was now going through the assessment stage before taking off on the next. "It can be said that biologists, biochemists and biophysicists are all involved in unravelling various aspects of life's mystery".

Shri Sethna said that it had been the tradition of the Bhabha Atomic Research Centre to encourage basic research in areas in the forefront of the various branches of science with a view to bringing about broader applications of research results. While the BARC largely gives emphasis to biological research in relation to radiation, he said its Biomedical Group, in keeping with established tradition, had also been working in several areas of basic research. Shri Sethna added that it was the practice of the Department of Atomic Energy to provide a proper forum for encouraging research and for dissemination of knowledge through symposia such as the present one. ●

Nuclear Round-up

(Continued from page 12)

Cancer Detecter

Research has led to the discovery that gallium-67, given as a simple salt, is a promising radioisotope for the detection of cancer. Trials in patients have continued to show a striking degree of localization of the isotope in many types of malignant tissue; and a gallium isotope may be useful also in therapy.

Virus particles have been isolated from cattle with lymphocytic leukemia. This finding of a bovine leukemia virus, along with recent evidence of a virus basis for feline leukemia, lends support to the theory that human leukemia may also be of viral origin.

(*US Atomic Energy Commission; Financial Report* 1970)

(Continued from page 5)

might occur again. The need for immediate corrective action needs to be emphasised and reemphasised.

To make the plant a safe place to work and the world a safe place to live in, everyone must practice, promote and preach the principles of accident prevention.

Safety is regarded by some, even now, as an extra, instead of a normal part of the working practices and business policy. Unfortunately, a great deal of complacency still exists just because some are of the opinion that "It does not matter where you are, flying in a plane or asleep in a bed. When your number comes up, that's it." They feel that all accidents are acts of God. If this theory was true, there would be no need for protective devices on the machines, protective equipment for personnel undertaking potentially hazardous jobs or the numerous other measures that are taken to control accidents. There are some others who consider all accidents as the inevitable price of progress. They conclude that exposure to modern technological development must inevitably lead to accidents. But, exposure to danger does not mean that safety cannot be a part of the process. While a calculated risk is involved in undertaking the various jobs, man has achieved considerable progress with safety. Safety research indicates that the overwhelming majority (98%) of accidents are of the preventable type.

Integral Part

ANOTHER view which is prevalent is that a number of people are accident prone. This has led to the theory that accident proneness is the cause of a significant percentage of the accidents. Where a person does experience repeated accidents, the cause generally is a number of inherent conditions related not only to his physical or mental make-up, but also to the environment in which he works. The real challenge is, hence, to identify these causes and to take corrective actions.

Safety must be an integral part of any industrial undertaking; it must be built in at the design stage, in production planning and in operator training. Safeguard features should be engineered into the plant to enhance the intrinsic and natural safety of the plant, and to reduce the probability and consequences of accidents. The designer should emphasise those practical design features that ensure reliability, provide for easy maintenance and result in a fail-safe system. The equipment fabricator should make certain that the quality of his workmanship is the highest possible. Installation, testing, operation and maintenance of equipment should be done with similar care. Malfunctions should be guarded against by design, fabrication, quality control, redundancy, failsafe features, inspection or operation, as may be appropriate. Adequate administrative procedures for operation, maintenance and inspection of the systems must be available. It must be recognised that in the long run, the safest equipment may well turn out to be the most economical to operate. The employer should ascertain that maintenance is effective and that problems are not allowed to go unattended because of the pressures to achieve a high-use factor. Failure to solve such problems may eventually result in accidents. It is short-sighted and, sooner or later, expensive to operate a plant in a sloppy, poorly maintained or potentially hazardous manner.

The employer must establish fair and easily understood safety rules and enforce them consistently. Commonsense would convince most employees that safety rules should be followed. But, there might always be the small minority who insist upon ignoring the rules. Experience indicates that with such people, disciplinary action must be taken, in the interest of safety. If corrective action is not taken, the rules soon cease to exist.

In deciding how far an existing installation should be preserved and how far it should be modified to meet safety ends, the management ought not to be swayed by considerations of short term profit or less. Moreover, they should not be influenced by an irrational prepossession in favour of the latest technological innovation. If technology is not useful, it is certainly valueless and possibly detrimental.

The managements of industrial enterprises should take an enlightened attitude towards the problem of accident prevention.

Safe working procedures do not arise spontaneously, they have to be devised and enforced. This can be done effectively only if the boss not only wants safe procedures, but is seen to want them.

ACCIDENTS DO NOT JUST *HAPPEN*

WHILE the role of the safety department should be advisory, it should have adequate prestige and authority, matching with the responsibilities, to serve the intended purpose. To be effective, it should have an important position in the heirarchy of management. Sufficient executive support is a must for a good safety programme. Little good could be achieved without the approval and support of the management. However, without the active cooperation of the worker, the employer cannot eliminate all accidents solely by his efforts. All possible hazardous conditions, unsafe acts or other problems cannot be anticipated by any one and hence each employee has to use his imagination, commonsense and self-discipline to protect himself in an emergency. As such, each worker should be stimulated to think beyond his immediate work in order to act safely in difficult situations entirely by himself. The challenge of true accident prevention is to

(Continued on page 9)

Molecular Biology & Brain Function

(Continued from page 3)

and some physiological aspects of differentiation in blue green algae are being investigated by scientists of this Centre.

Embryonic differentiation can now be made to occur in tissue culture. Identification and isolation of specific factors that normally induce a cell to differentiate in a given direction would be a major step towards the solution of the mysteries of differentiation. Striking differences have been observed in the surface properties of normal and transformed cells in terms of antigenicity and interactions with agents like lectins. The tissue culture technique has also yielded useful information on the patterns in which a normal cell undergoes transformation to cancerous state. Marked changes in histological and histochemical patterns and in the induction of certain enzymes in liver have been observed in our laboratory to precede neoplastic changes due to orally fed hepatocarcinogens.

Very significant advances in our understanding of the molecular basis of transformation are being made with the animal tumour viruses, *SV* 40, *Rous sarcoma* and *polyoma*. Other studies are being directed on the factors leading to loss of cellular affinities during malignancy. In considering practical applications, it would be most advantageous to attack the long chain of processes representing carcinogenesis in its weakest link — which is undoubtedly the period of dormancy. Recent observations strongly indicate that human breast cancer may also be a viral disease. They also give us great hope that cure for at least some of the human cancers may be forthcoming.

Molecular Biology and Brain Function

Perhaps the greatest challenge at the present time lies at the frontier of research pertaining to structure and function of the nervous system. It is not a new frontier, for scientists have investigated it for long, even breaching it at points during the past few years. But the subtletly and complexity of the problem are so great that effective attack on them has had, in many cases, to await the development of more delicate and penetrating tools, both physical and theoretical. It has now been realised beyond reasonable doubt that transmission of impulses between neurons in the mammalian nervous system is by means of chemical agents. Exciting research is underway on the mechanisms by which these agents communicate between nerves and muscle. The recent isolation of the cholinergic receptor protein from electric organ of the fish, *Torpedo marmorata* and of a specific protein capable of transferring fear of darkness from trained rats to others into which it is injected, represent important landmarks in elucidating molecular mechanisms of neural function and behaviour.

The Future

The approach, hitherto, of analysing cell components — from the organism to the tissue to the cell to molecules — has resulted in spectacular achievements in our knowledge of discrete cellular activities. But, it now appears that this is a relatively easy road when one compares it with the uphill task of getting back from molecules to the structurally and functionally integrated cell. Can what we dissemble on the way down be replaced in the reverse order and the system reconstituted? There has been an obvious disproportion between the relative abundance of information about molecular and supramolecular entities *per se* and dearth of *in toto* knowledge of their complex interplay. Undoubtedly, study of their interactions should command a large share in the blue print of future research on cellular processes, aided by new instruments, techniques and concepts. Such an approach is indeed essential to build further on the firm foundations upon which the life sciences now rest and to reach newer heights. ●

Accidents Do Not Just *Happen*

(Continued from page 8)

change attitudes of mind by efficient and regular safety training for all levels of management and workers. The aim must be to make every individual have more regard not only for his own personal safety, but also for the safety of others. Safety is everybody's business, everyday.

However, the human mind is funny. It gets used to things very quickly. The commonplace things, irrespective of their seriousness, grows unimportant and goes unnoticed. For example, a cyclone killing 10 people is front page news. But the 500 fatal accidents, a lakh of serious injuries and a larger number of minor accidents that take place in our industries every year is not significant news. Moreover, even when some are shocked to realise the consequences of an accident, they feel that accidents take place with others, but not involving themselves. This complacency spawns inattention which is the greatest single cause of accidents. Their minds stray somewhere else and their eyes wander away. They become careless and the unfortunate result is the unexpected accident with its disastrous consequences. The problem of accident prevention remains as one of the greatest challenges of the present day. Tens of thousands of persons are killed and millions injured throughout the world every year. The scope of the problem is still increasing as more and more industries, with more complex processes and techniques, are growing up. Experience has shown that by means of cooperation and joint effort by employers, workers and governments, this dreadful toll can be reduced. It is consoling to learn that there is no hazard or operation that cannot be overcome by practical safety measures. Only a general recognition of the continuing need for a serious and devoted struggle to reduce accidents and to preserve life and limb, can solve the problem that exists in this important field of human endeavour. ●

Food Irradiation Technology Has Great Relevance to Developing Countries

BY H. N. SETHNA
Director, Bhabha Atomic Research Centre

THE Bhabha Atomic Research Centre has been concerned with research and development efforts on the harnessing of nuclear energy for peaceful purposes and has accorded priority to projects pertaining to food and agriculture. From embryonic beginnings a few years ago, our work on radiation preservation of foods has been steadily stepped up and, with the installation of needed facilities at the Food Irradiation and Processing Laboratory at Trombay, we have developed some of the promising processes to the point of practical application.

At the time we launched our own programmes of work in this field, an impressive amount of research efforts on food irradiation, as well as on the assessment of safety of irradiated foods, was already in progress in many other countries. It is unfortunate that, in spite of significant achievements during the past decade or so, the pace of progress towards commercial utilisation has hitherto been only in terms of faltering steps.

I would, therefore, like to share with you my thinking and our concern at this undue delay, as well as avoidable road-blocks, in the widespread adoption of this technology. It seems to me that, if radiation preservation of foods has, for the major part, still remained an objective, it is not so much due to an underestimation of its potentialities for good but to the prevalence of prejudices, unfounded fears and irrational approaches.

Most of the advances in food irradiation have taken place in the more industrialised nations of the world, notably the USA, where the need for this new technology has perhaps hardly existed. In addition to favourable climatic conditions and better modes of handling, storage, transportation and retailing of perishable foods, the existence of an organised and well-established conventional food processing industry in these regions has obviously retarded the introduction of a newer process and an objective assessment of its merits.

Another major reason for the slow commercial progress of food irradiation has been the decision of the U.S. Food and Drug Administration as well as some other national regulatory agencies to categorise radiation preservation as akin to the use of food additives. Accordingly, safety of radiation processed foods for human consumption has to be established by procedures and protocols recommended for food additives. This, in addition to being expensive and time consuming, may not always be either practical or realistic for safety evaluation.

Let me take a little time at this point to bring out one or two fallacies of this approach.

Much has been made about possible chemical changes in irradiated foods. One must remember, however, that even conventional methods of food preservation or, for that matter, several culinary practices, could equally well result in chemical alterations to varying degress. For example, to achieve equivalent microbicidal effect, the required input of thermal energy is much more than ionising energy and there could, therefore, be far greater production of free radicals due to heat treatment, especially with certain types of food.

Again, the testing of a food additive requires that it be fed to experimental animals in large quantities for toxicity challenge. There is a cardinal error in applying this procedure to irradiated foods and, therefore, in insisting that large quantities of the test diet itself be fed. Excessive ingestion of a variety of dietary essentials, such as calories, proteins, fats, vitamin A, calcium and so forth, can lead to metabolic disturbances or toxic manifestations. Can this be construed to mean that these nutrients pose potential hazards as poisons?

Let us examine the situation from another angle. Most food materials inevitably contain some chemical components about which little is known. Thus, every day, many unknown chemicals are consumed and the more 'natural' the diet, the wider the range of these unknown chemicals is likely to be. It may sometimes happen that such naturally occurring chemical substances are toxic. For instance, several pharmacologically active principles are known to be present in legumes, a widely consumed and rich source of proteins. A variety of other plant products contain potent toxins—solanine in potato tubers, for example. Considerations such as these expose the myth that 'processed foods are not as safe as natural foods' or that 'synthetic chemicals or additives are inherently more dangerous than those of natural origin'. It would seem, on the other hand, that the presence of unknown impurities is usually a greater problem with natural than with processed products.

By advancing these arguments, I am not for a moment detracting from the need for protecting the consumer by ensuring that new foods or additives or processes to which foods are subjected are safe, to the extent it is possible to determine. I merely want to emphasise the fact that every biosystem has a definite threshhold level for practically any toxin. Hence, their presence in foods does not in itself portend danger. They do so only when, in the amounts they are likely to be consumed, they rise above the threshhold. The concept of a substance being 'poisonous *per se*' has perforce to be abandoned in favour of specifying realistically based tolerances.

(Continued on page 11)

Food Irradiation Offers Major Incentives to Developing Nations

(Continued from page 10)

During recent years, there has been a general recognition that early protocols for toxicity testing did not detect *subtle* population hazards. In consequence, biological testing procedures for ensuring safety are being made increasingly rigorous. Additionally, advances in methods of ultra-fine analytical determinations have been steadily pushing down the lower limits of detection. With such innovations, there has been a growing awareness for a reappraisal of the possible harmful effects due to all types of environmental factors—radiations, drugs, chemicals in foods and others, including even air and water. It is in this context that, in considering clearance of radiation sterilised bacon and ham, the US FDA took a decision that the original data, based on techniques developed decades ago, may not be adequate at the present time. Newer protocols, based on the most recent toxicological procedures, are therefore currently being used by the US Army to evaluate the safety of radiation sterilised foods. In the mean time, this has apparently caused a slackening of efforts in the application of food irradiation processes.

The point I would like to make here is that the question of possible toxicity is not unique to irradiated foods, but is one which should be considered for all substances, including all processes to which food is subjected. Viewed in this perspective, food irradiation has already shown new promise, since wholesomeness evaluation studies on irradiated foods represent to date the largest and most impressive toxicological screening ever undertaken.

In regulatory work affecting large population groups, there is need for developing objective approaches that recognise the balance between the benefits and risks of any process or procedure. This is a delicate task that has to be carefully carried out, especially where hazards are imprecisely known or have been shown to be unreal and where there is no such thing as 'absolute' or 'guaranteed' safety.

In spite of the set-back that has admittedly resulted from the US FDA action, notable progress has been made in the past few years, especially in the application of *low dose* radiation procedures for food preservation. Several countries, including the USA have cleared a variety of irradiated food items. Netherlands, Israel and USSR have carried out field trials with certain radiation processed foods following clearances. I understand that approvals for shelf-life extension of strawberries and papayas in the USA, white fish in the UK and shrimp in Netherlands, are all expected shortly.

Of significance is the renewed interest in several of the European countries as well as among international agencies. A joint FAO/WHO expert group has initiated recognition of irradiated foods by recommending provisional clearances for radiation-disinfested wheat and for sprout-inhibited potato. An international centre for wholesomeness testing of radiation processed foods has been set up with support from several European and other countries. The technical basis for uniform legislation for irradiated foods in different countries is under examination by the IAEA.

It is to the developing nations of the world, lying in the tropical regions, that the adoption of food irradiation offers major incentives and special advantages. These relate to adverse climatic conditions and high spoilage losses, gross food insufficiency and malnutrition, inadequate handling, storage and transportation facilities and, last but not least, the lack of competitive and alternate preservation technologies. It is my firm belief and hope that, if only because of these unique considerations, the developing nations will take a lead in these applications for others to follow.

I mentioned at the outset that we in India have been building up our efforts. Based on our own extensive researches, including evaluation for safety and agro-economic analyses, as well as the experience obtained elsewhere, we have, at the present time, selected certain promising processes using low dose irradiation procedures for practical adoption. We are now examining legislative and other aspects for the setting up of pilot-scale operational units. To this end, we have initiated discussions with our ministries of Health, Food and Agriculture. ●

Trombay Course in Irradiation Technology

(Continued from page 1)

tion of spoilage micro-organisms. He disclosed that in cooperation with other government agencies, regulatory aspects for setting up pilot plant facilities and for follow-up studies relating to production schedule and operation, were being examined.

In his inaugural address, the Director of the Bhabha Atomic Research Centre, Shri H. N. Sethna, dwelt on the "undue delay as well as avoidable road blocks" in the widespread adoption of food irradiation technology. This technology he said, had made great advances mostly in the industrialized nations of the world where, paradoxically, the need for it hardly existed. Also, he said existing built-in prejudices against radiation preservation, especially in the United States, had retarded the introduction and widespread application of this process. It was unfortunate, he said that inspite of significant achievements in the past decade or so the pace of progress towards commercial utilization of this technology had been only in terms of faltering steps (*See page* 10).

Shri M. A. Hadi, Joint Secretary in the Department of Atomic Energy and Dr. H. E. Goresline of the IAEA, who was co-Director for the Course, welcomed the participants on behalf of the Government of India and the IAEA respectively. ●

Round-up of World Nuclear News

Japan's Nuclear Ship

Japan's first nuclear-powered ship "N. S. Mutsu" is going through the last stages of construction as the world's fourth non-military atomic vessel, following the "Otto Hahn." Its home port is at the northernmost part of Japan's main island, at the City of Mutsu, Aomori Prefecture.

Completion of 'Mutsu' will cost 18,000 million yen ($50 million).

The 'Mutsu', including its reactor, is being built under Japanese engineering techniques to the greatest possible extent. Although the fuel UF_6 will come from the U. S. A., most equipment is being manufactured by Japanese makers with a few exceptions.

(*Atoms in Japan*, Sept. 1971.)

Japan Gives Go-ahead to Nuclear Fuel Processor

The Japanese government has just sanctioned the nation's first nuclear fuel processing plant, to be constructed by the Power Reactor and Nuclear Fuel Development Corporation (PNC). Already Japan has four nuclear power stations in operation — with a total output capacity of 1323 MW — and a further nine units under construction. By 1977 the nation will have 13 nuclear power plants, with an estimated total capacity of 17,300 MW. By then these plants will have accumulated some 630 tons of spent fuel which will be worth approximately 13,000 million yen ($38 million). Reprocessing of this fuel at home will allow some of this material to be reused without wasting valuable foreign exchange. Japan, reliant as it is on imports for virtually all of its nuclear fuel, must clearly make an early start on the establishment of spent fuel reprocessing, if its nuclear power development project is to advance smoothly.

PNC had originally planned to start building its plant back in 1967 but strong opposition from people living near the proposed site — fearing possible accidents from a nearby American firing range — delayed the project. The firing area has recently been returned to the Tokyo government, however, and negotiations with the area's residents have progressed smoothly enough to lead the authorities to approve the reprocessing facility's construction.

(*New Scientist*, Sept. 30, 1971)

Plowshare Programme

The objective of the United States' Plowshare programme is to develop economical and safe industrial, scientific, and civil engineering applications for nuclear explosions. Research and development effort is directed toward increasing the knowledge of the effects of underground nuclear explosions and to develop the special nuclear explosives necessary to meet the requirements of specific applications.

The following effects of underground nuclear explosions have been identified as having potentially practical uses: (1) the chimneying effects of deeply buried nuclear explosions; (2) the creation of sunk craters produced when chimneying is permitted to reach the surface; (3) the retarc, or mounding effect of explosions buried relatively close to the surface; and (4) the creation of throwout craters from relatively shallow explosions. Chimneys appear promising for the development of natural resources.

The cratering technology is being developed for large-scale earth moving projects such as harbours, mountain passes for highways and railroads, and canals — projects which have not been economically feasible or beyond the capability of chemical explosives and earth moving machinery.

(*US Atomic Energy Commission, Financial Report* 1970)

Bigger and Better Breeders

While Britain is bent on a 1300 MW(e) first commercial FBR, and some bodies in the U. S. A. favour 2000 MW(e) as the size to go for in a commercial plant, Germany seems to be thinking in terms of 3000 MW(e). At a round table discussion on FBR developments, top F. G. R. FBR man Dr. Hafele suggested that FBR plants of from 2000 to 3000 MW(e) would be a better proposition than the 1000 MW (e) stations planned for joint construction under the EDF-RWE-ENEL partnership.

German specialists at Geneva were feeling happy about two important land-marks on the research side — (a) the initial criticality of the KNK 20 MW sodium cooled reactor at Karlsruhe at 7.42 on August 20, and (b) the successful completion of the important transient test programme, the final major test programme for the SEFOR first core undertaken jointly with GE in the U. S. A. Some, however, had sad forebodings that there would be further irritating delays in the final contract agreement for the SNR plant beyond the end of 1971.

(*Nuclear Engineering International*, October 1971)

Californium-252 for Universities

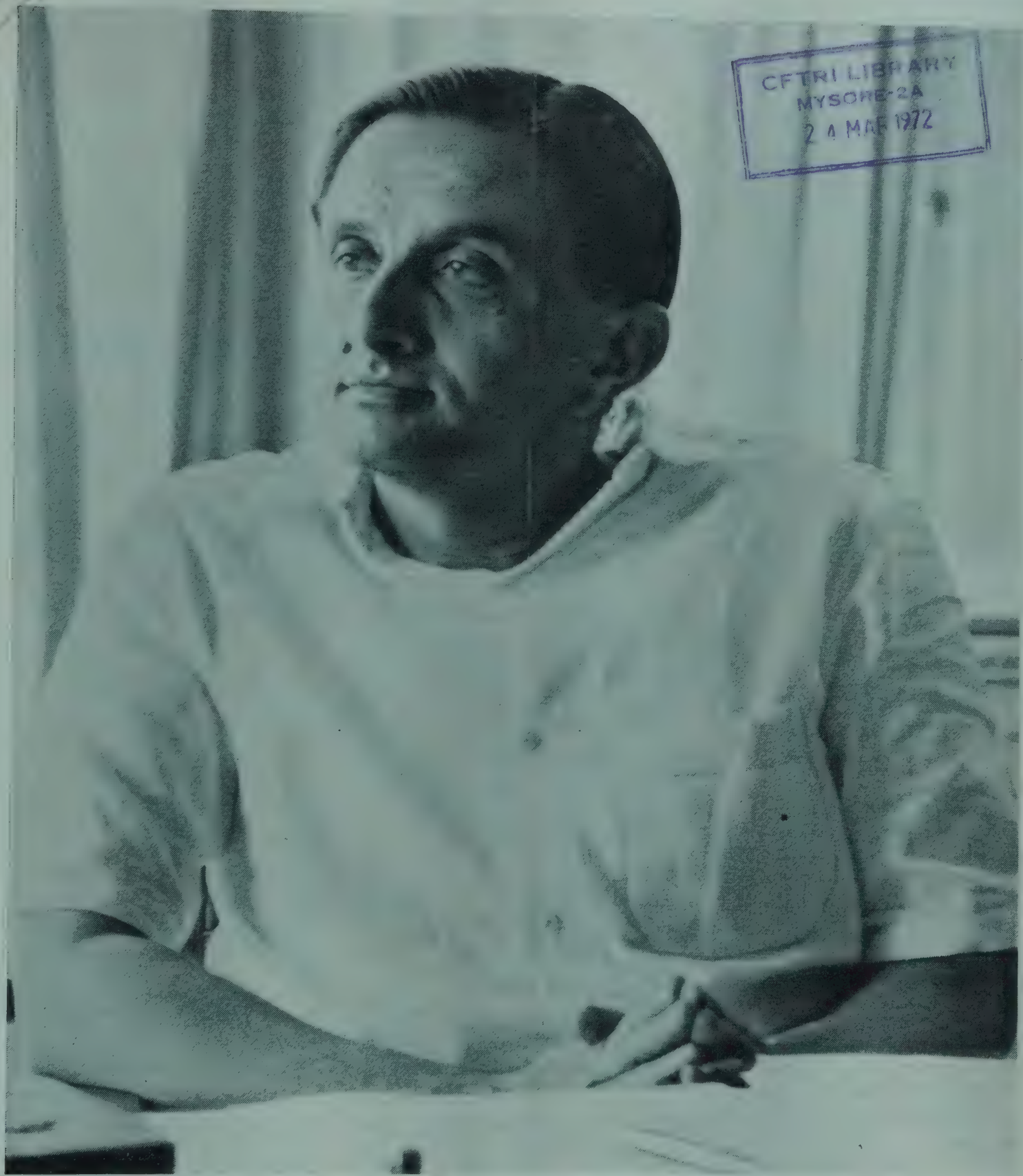
Several needles containing small quantities of californium-252 will be given by USAEC to the International Atomic Energy Agency for distribution to universities in IAEA member states. Presently on loan to foreign medical institutions, the needles will be transferred to the universities when they have decayed so far as to be no longer useful in medicine. The first should be available about 18 months from now.

(*Nuclear Industry, Part II*, October-November 1971)

(Continued on page 7)

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 1, and printed by him at Conway Printers Pvt. Ltd., 167c, Dr. A. B. Road, Worli, Bombay 18.

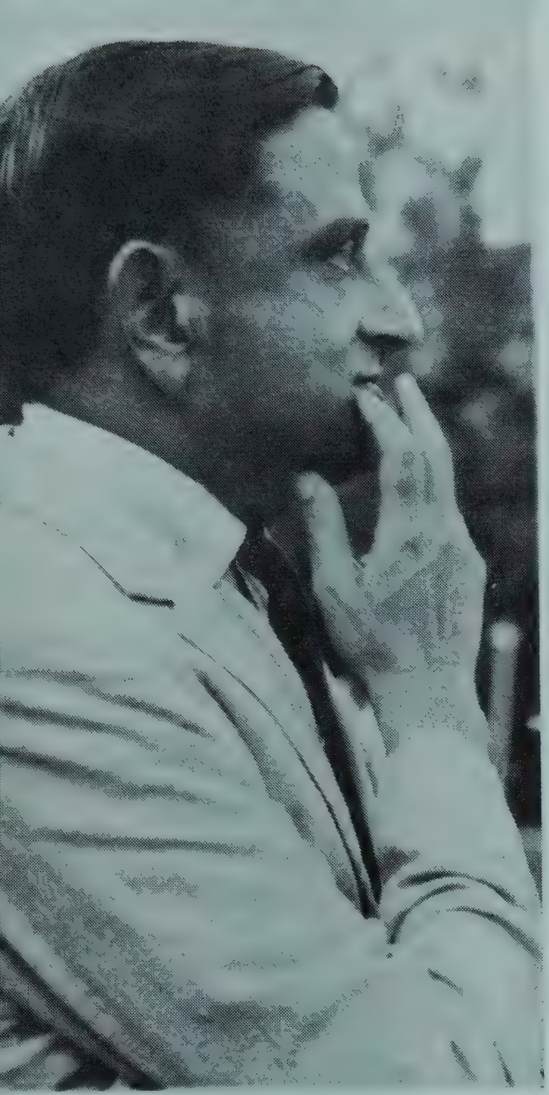
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VOL. 10. No. 5 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY JANUARY 1972



THE MAN WHO COULD SEE SQU

"To make life a dream and to turn the dream into reality," is the object in life, said Pierre Curie. Both Vikram Sarabhai and Homi Bhabha could be said to have lived by it, combining in themselves that rare blend of the dreamer and the pragmatist. In 1944, when nuclear energy was still in its infancy, Homi Bhabha had visualised a time when "India will not have to look abroad for its experts, but will find them ready at hand," and had built the schools and the laboratories to realise it.

Vikram Sarabhai continued with vigour his distinguished predecessor's work in nuclear energy and added a new dimension to it in space research. He envisioned in the country in the not-too-distant future "large nuclear power stations serving agro-industrial complexes, synchronous satellites used for mass communication through direct broadcast television, for promoting national integration and literacy, for meteorological observations covering the vast Indian ocean, for surveying the mineral resources of the sub-continent..." and the many other almost unlimited applications of the nuclear and space age beneficial to a developing nation. During his tenure a great impetus was given to projects of significance to the country including the study of the concept of the nuclear powered agro-industrial complex, work on breeder technology, and the build-up of the electronics and other vital sectors of advanced nuclear and space technology.

Coupled with this forward outlook was his impatience with the pace of development. He urged the infusion of an innovative spirit in every sphere of endeavour, underlining especially the need for applying the most advanced technologies and management practices to raise the country from backwardness and poverty. "There is a totality about modernisation" he said. "There is no hope for those who wish to advance step by step following outmoded methods. We cannot have 20th Century atomic energy or space research with 19th Century industry or antiquated systems of management and organiza-

ELS AND BIRDS

tion".

With the grudging acceptance of the reality as we know it, a great man who is no more acquires a new meaning for the individuals and the institutions close to him. In the recollection and recomposition of the varied images of his personality and qualities, there is the compulsive urge to understand the man in his totality. A scientist, administrator and a warm human being, despite his stupendous workload and responsibilities, he remained the same sensitive man intensely responsive to the beauty of life and the environment around him. "In creative work one should be able to see squirrels and birds," he had said last year while paying homage to Homi Bhabha.

Sarabhai remained always the socially committed scientist deeply concerned with improving the quality of life of the masses with the aid of science and technology. His vision of the future and the comprehensive programme he initiated to realise it are his inspiring legacy to his countrymen. ●

Tributes

The President

Dr. Sarabhai was one of India's outstanding and internationally known scientists and had been a pioneer in the field of science. With his dynamic outlook, he had made signal contributions towards increasing human welfare through the use of science. In his untimely demise, the country has lost an eminent son whose life was one of total and unostentatious devotion.

The Prime Minister

Dr. Vikram Sarabhai's sudden and untimely death has come as a terrible shock. He was young, and seemed so well. I am deeply grieved. Dr. Sarabhai was one of the brilliant young scientists who are helping to give a new image to our country. He served India through his personal contribution and through the imagination and drive with which he directed the work of the Atomic Energy Commission. He was active in many international scientific spheres.

Apart from his research, what lifted him above the ordinary was his intense concern with the relationship of science to the larger purposes of human life. He had much to contribute and will be greatly missed.

Dr. Kurt Waldheim

(Secretary-General, United Nations.)

The death of Dr. Sarabhai is a loss as much to India as to the international community. He had a great interest in the application of space technology to development and was interested in experimenting in new ways of applying space technology for this purpose.

I had the privilege of associating and collaborating closely with him during the United Nations Conference on the Peaceful Uses of Outer Space held in Vienna in 1968, as well as in the activities of the International Atomic Energy Agency. In all of these activities he served with distinction and with a rare sense of personal commitment and devotion.

U Thant

(Former Secy.-General of the United Nations)

Dr. Sarabhai was a brilliant and true patriot. He devoted all his talents and energies to the advancement of India in the technological and scientific fields, and especially in the application of atomic energy for peaceful purposes and space technology for economic development. We in the United Nations will miss him at various meetings.

Dr. Sigvard Eklund

(Director-General, IAEA)

Although we all know that life is fragile, a reminder of that fact still takes us by surprise and we are shaken in our belief of personal immortality which we, at least in this part of the world, almost take as a matter of course. Dr. Sarabhai will be long remembered in the International Atomic Energy Agency for his important contributions and by his many friends, including my wife and myself, for his fine personality and warm friendship.

Shri H. N. Sethna

(Chairman, AEC and Director, Bhabha Atomic Research Centre)

He was a typical example of a citizen of modern India, a person with a scientific approach to exploitation of science, specially space and atomic energy for peaceful purposes. He was greatly influenced by the teachings of Mahatma Gandhi. His picture of India was that of a highly developed nation in the field of science and technology yet never forgetting its mission of propagating peace on earth.

Dr. Sarabhai was a great believer in international cooperation. It was he who spearheaded and made possible our friendship in matters of atomic energy with the South East Asian countries. He will always have a corner in our hearts as a man of peace, as a man of science and as a man who always took a deep interest in the personal welfare of all his colleagues.

(Continued on page 12)

Vikram Sarabhai - Some Re

A man of varied interests, Dr. Sarabhai brought into everything he did an intellectual perspicacity and deep personal involvement. His views on important sectors of national planning, especially on atomic energy and space research reflect a strong commitment to the country's goals and aspirations. Following are extracts from some of his speeches and writings, ranging from his views on an approach to planning for atomic energy and space research, the relevance of space research to a developing country, to the place of fundamental and applied sciences and their interrelation.

An Approach to the Future

THE progress of science and technology is transforming society in peace and in war. The release of the energy of the atom and the conquest of outer space are two most significant landmarks in this progress. Largely due to the consistent national support which the programmes of the Atomic Energy Commission have received since Independence, India is amongst the nations of the world advanced in atomic energy, and is striving for a similar position in space technology and research. There are those who preach that developing nations must proceed step by step following the same process by which the advanced nations themselves progressed. One is often told that such and such a thing is too sophisticated to be applied. This approach disregards what should perhaps be obvious, that when a problem is great, one requires the most effective means available to deal with it.

The seeming disadvantage of a developing nation such as India, which has only a limited existing technological infrastructure to build on, can be an asset rather than a liability. I suggest that it is necessary for us to develop competence in all advanced technologies useful for our development and for defence and to deploy them for the solution of our own particular problems, not for prestige, but based on sound technical and economic evaluation as well as political decision-making for a commitment of real resources. The traditional approach of planning to provide things like electric power or telecommunication services for a national infrastructure, based on projections of growth from past experience is inadequate. An alternative approach lies in creating consumption centres alongside facilities for supply, as for instance an agro-industrial complex served by a large nuclear power station or a programme for television to the entire countryside using a direct broadcast synchronous communications satellite. Indeed there is a totality about the process of development which involves not only advanced technology and hardware but imaginative planning of supply and consumption centres, of social organisation and management, to leapfrog from a state of backwardness and poverty.

Nuclear power is today essential for economically supplying energy in large parts of the country, and is moreover the only major supply on which we will need to fall back in perhaps less than 50 years' time.



With Prof. S. Chandrasekhar of the University of Chicago.



With Prof. P.M.S. Blackett of the Central Advisory Council for Science and Technology, England.

We therefore need to commit ourselves to an appropriate programme of atomic power stations. We cannot hope to gain all the great economic advantages of nuclear power unless we develop a mix of thermal and advanced fast breeder reactors. It is my firm belief that the problems of poverty and regional imbalances in our country cannot be effectively tackled without it.

Several uses of outer space can be of immense benefit to us as we strive to advance economically and socially. Indeed without them it is difficult to see how we can hold our own in a shrinking world. The greatest cost/effectiveness of the uses of outer space occur through large scale applications rather than those of limited scope. A communication satellite can most effectively

serve communities dispersed over large areas. Meteorological applications of satellites are likewise most relevant for a global system like the World Weather Watch.

It is possible to develop atomic energy and space research through basic, applied and developmental research in islands largely isolated from the rest of the country, but large scale applications of either for the benefit of the nation cannot be undertaken in isolation. We cannot have 20th Century atomic energy or space research with 19th Century industry or antiquated systems of management and organisation. There is a totality about modernisation, and in order to gain confidence, we must experiment with our resources even at the risk of failure. We have to rise from an in-built culture within which a major departure from an existing well-proven system and anything which is innovative in character is automatically regarded with suspicion.

There might be many opinions concerning what would be an advantageous course to follow in the short run, but 10 or 20 years from now, when the population of India would be somewhere between 750 and 1000 millions, it can hardly be controversial that we would need a very strong base of science and technology, of industry and agriculture, not only for our economic well-being but for our national integration and for ensuring our security in the world. The profile of development, during the present decade, of atomic energy and space research carrying with it advances in fields such as metallurgy, electronics and instrumentation as well as computer sciences has been fashioned to provide a viable future. Advances in science and technology are accompanied by rapid obsolescence of existing systems. Recognising that we do not wish to acquire black boxes from abroad but to grow a national capability, we should note that our plans have to be continually updated and even the strategy altered as we proceed. In many innovative tasks, forward planning and cost estimates can only be adhoc and this has inherent limitations.

It is hardly necessary to emphasise that for projects which take five to seven years to complete, we have to look at least ten years in advance if our progress is not to be halting and results mediocre. The programme that we envisage is ambitious, but achievable.

(*Introduction to "Atomic Energy and Space Research — A Profile for the Decade* 1970-80", *May* 1970)

* * *

A LONG TERM plan backed by appropriate commitment of funds, personnel and facilities for taking the benefits of atomic energy to the large number of developing nations is essential if the problems which are likely to be faced in the world in the next decade are to be effectively tackled. We should note that unless we adopt very special measures involving new norms of international collaboration and assistance, the gap between the atomically advanced nations and those not yet in this category, will rapidly widen as in other areas of development. Moreover, if the full benefits of atomic energy are not quickly harnessed for development, we shall be creating economic and social conditions far more dangerous to the security of the world than the clandestine diversion of fissile materials for military use, the prevention of which we are all anxious to ensure. It is my conviction that just as major hydroelectric and irrigation schemes related to common natural resources tie together the economic viability of nations and put a premium on co-existence overriding political differences, so can low cost nuclear energy centres provide the forces of social and political cohesion in all regions of this troubled world.

(*From Presidential Speech at the 14th General Conference of IAEA, Sept.* 1970)



With Mrs. and Dr. Kurt Waldheim, the present U.N. Secretary-General.

The Relevance of Space Research to Developing Nations

THE BENEFITS of the uses of outer space truly accrue only through international cooperation based on interdependence. Indeed, the situation here brings out dramatically a feature which is not peculiar to outer space but to many other fields of technological development; of monolithic technological systems created to serve social groups with diverse cultures, history and political objectives.

Space research shares with the growth of electronics and of atomic energy, the characteristic that its progress has depended very crucially on the interplay of fundamental sciences with technology. Just as solid state physics has contributed to electronics and nuclear physics to reactor technology, several fundamental sciences have contributed to space research. This has the important consequence of providing to the practical applications an inbuilt culture of international science — propagating beyond national frontiers, permitting two-way communications not constricted by commercial considerations nor even subject to effective containment on national considerations.

This Conference is to lay special emphasis on the benefits which can be derived by developing countries from participation in the peaceful uses of outer space. The primary concern of such nations must presumably be social and economic development, and indeed during the last 20 years, we have seen an increasing realisation, at least intellectually, of the grave threat that exists to the security of the world through wide disparities in the standards of living in different regions. But a relevant question to ask in this context is, why, in spite of much that has been attempted bilaterally, regionally and through international agencies, the gap between the advanced and the developing nations has widened rather than decreased? In examining the question from a different angle, I have asked myself the question why is India one of the most expensive poor countries? I could observe two important factors. First that since developing nations by definition start from a low economic base, their incremental growth, large as it might be when expressed per cent wise, is intrinsically small, compared to the incremental annual growth even of much smaller economically advanced nations. Thus, a developing nation following a step-by-step approach towards progress is landed with units of small size, which do not permit the economic deployment of new technologies. Through undertaking ventures of uneconomic size with obsolete technologies, the race with advanced nations is lost before it is started. Indeed, if one continues to operate on this philosophy, financial and technical assistance from the advanced nations to the developing nations can only result in the frustration of the former and the increasing economic dependence of the latter.



With Dr. Sigvard Eklund, Director-General, IAEA, at the 14th General Conference of IAEA, September, 1970.

A positive approach out of this predicament seems to lie in finding solutions where the particular disadvantage of developing nations, which is that they have little to build on, is made an asset rather than a liability. I suggest that it is necessary for them to develop competence in advanced technologies and to deploy them for the solution of their own particular problems, not for prestige, but based on sound technical and economic evaluation involving commitment of real resources. They would most likely discover that the traditional approach of planning to provide things like electric power or telecommunication services for a national infrastructure, based on projections of growth from past experience leads to a dead end. They will also discover that an alternative approach lies in creating consumption centres alongside facilities for supply; that as in the case of large nuclear power stations serving agro-industrial complexes, synchronous satellites could be planned in the context of a programme to be simultaneously undertaken for direct broadcast television to the entire countryside. Indeed they would discover that there is a totality

about the process of development which involves not only advanced technology and hardware but imaginative planning of supply and consumption centres, of social organisation and management, to leapfrog from a state of backwardness and poverty.

Developing nations which have a large area and big population, such as India, have the possibility of effectively utilizing space communications systems for national needs. Compared to advanced nations such as the U.S.A., Canada and U.S.S.R., they have indeed an advantage through not having an existing major investment in older technologies. For them the principal problem is of mobilizing resources and of developing them adequately. The most important input I regard in this exercise is of course the human element of trained engineers, scientists and managers, of people who understand not only the technological but the social implications of the system which they wish to deploy. Developing nations differ widely in regard to existing human resources of the requisite type needed to partake in the peaceful uses of outer space. In India, for instance, when independence was achieved, there were in the country tens of thousands of engineers and scientists and several thousands abroad. The capability of such a country where scientific investigations dealing with meteorology, geomagnetism and astronomy have been conducted for more than 100 years and a sophisticated culture and tradition for learning exist, is quite different from that of developing countries with a much weaker professional base. True, that expressed as a per cent of population the number of professional scientists and engineers in countries such as India are small; but in absolute terms they compare well with the numbers that are found in nations such as Germany, Italy or Japan. Moreover, since advanced technologies require skilled personnel in large measure the situation is not different for advanced and developing countries. Under these circumstances, surely, the developing countries with a professional base have an economic edge in a straight competitive situation.

We often meet with lack of self-confidence to pursue major tasks involving complex and unfamiliar technologies. There is also an in-built culture within which a major departure from existing well-proven systems, and anything which is innovative in character is automatically regarded with suspicion. The administrative structure of Governments in many nations is dominated at the top not by technocrats but by professional administrators, lawyers or soldiers, who are hardly likely to provide the insights, experience and the first-hand knowledge of science and technology which are necessary at the decision-making level .... There are those who preach as guardians of the economic wellbeing of the developing nations that they must proceed step-by-step following the same process by which the nations themselves progressed. One is often told that such and such a thing is too sophisticated to be applied. This approach disregards what should perhaps be obvious, that when a problem is great, one requires the most effective means available to deal with it.

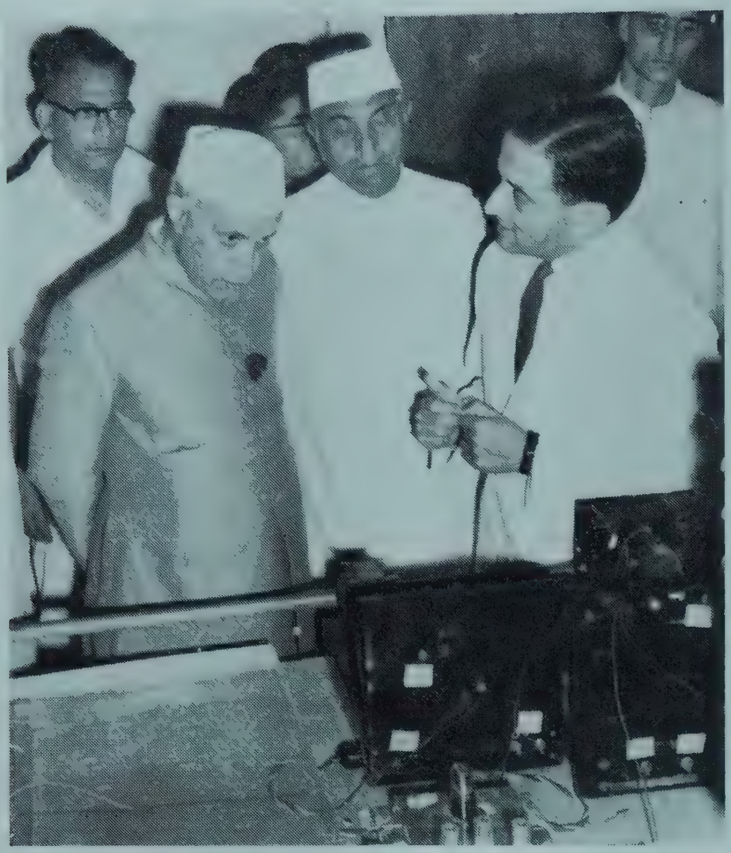
A physicist is trained to accept that what is not possible in theory, is not realisable in practice. This elementary experience can well be applied in planning international systems for promoting the peaceful uses of outer space; as indeed also for peaceful nuclear explosions. Those systems that do not provide full participation by all nations in all aspects of technology in which they are competent to partake in, are, in my humble opinion not saleable, much less sustainable in the long run. Attempts to promote them merely poison international relations and the climate of co-operation.

Speech at the U.N. Conference on Exploration and Peaceful Uses of Outer Space, Vienna, August 1968

With U.S. astronauts Neil Armstrong and Michael Collins at the TIFR, Oct. 1969.



Vikram Sarabhai... Some Re



With Pt. Nehru at the Physical Research Laboratory, Ahmedabad, April 1954. *Below.* With Shri K. C. Pant and Dr. Nag Chaudhuri at Space Science & Technology Centre, Thumba.

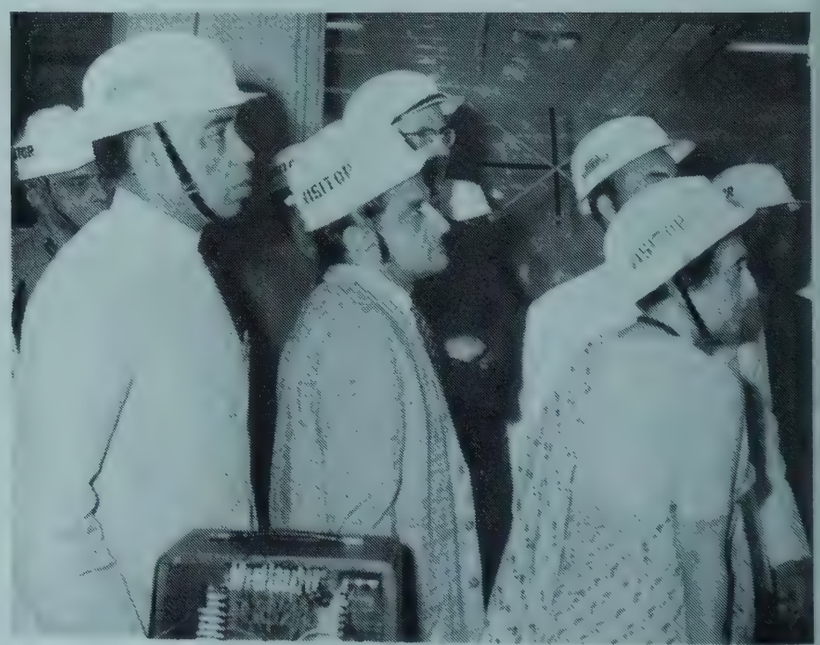




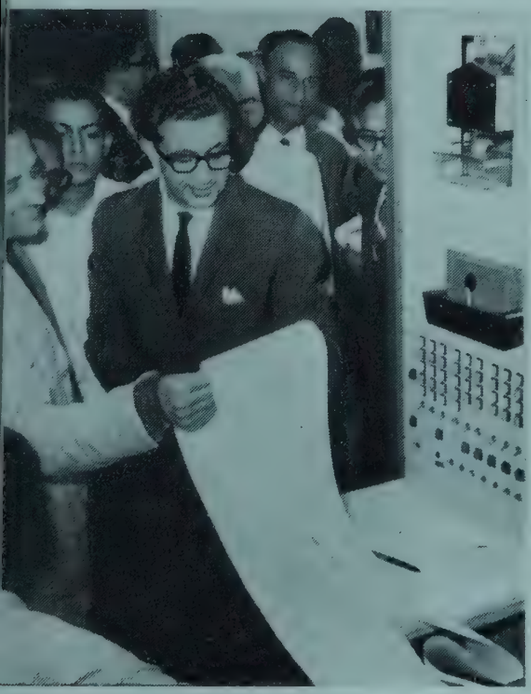
With the Press. *Below:* At the United Nations Conference on Exploration & Peaceful Uses of Outer Space, Vienna, August 1968.



Visiting Tarapur with the Prime Minister.

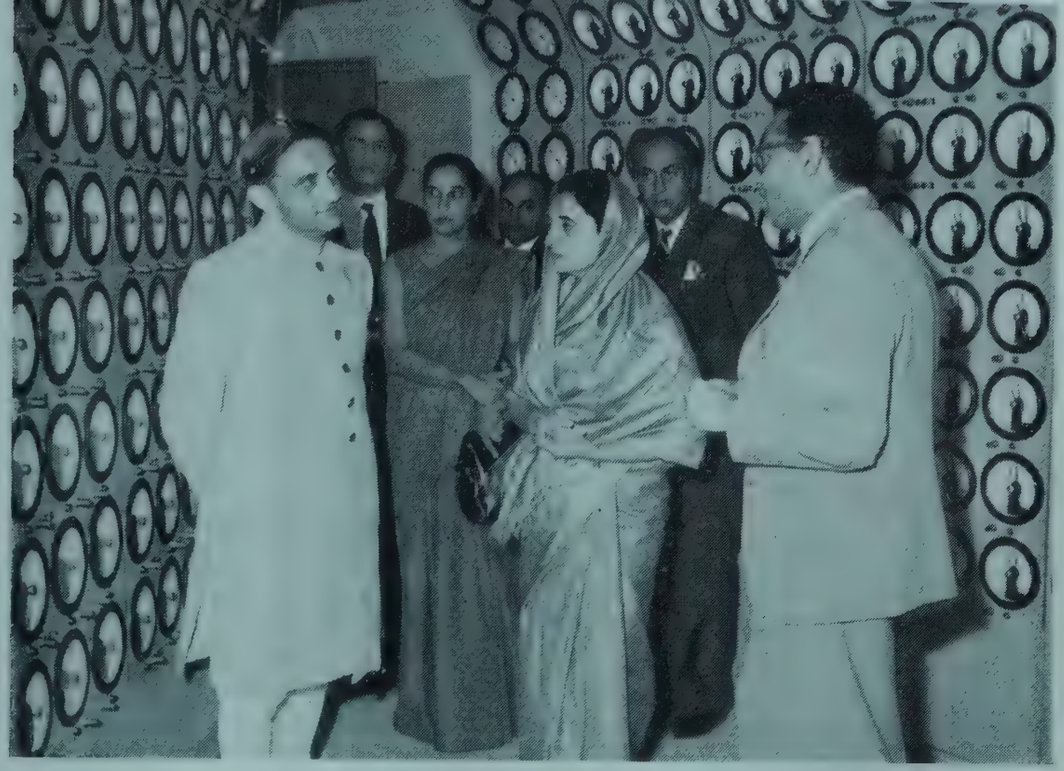


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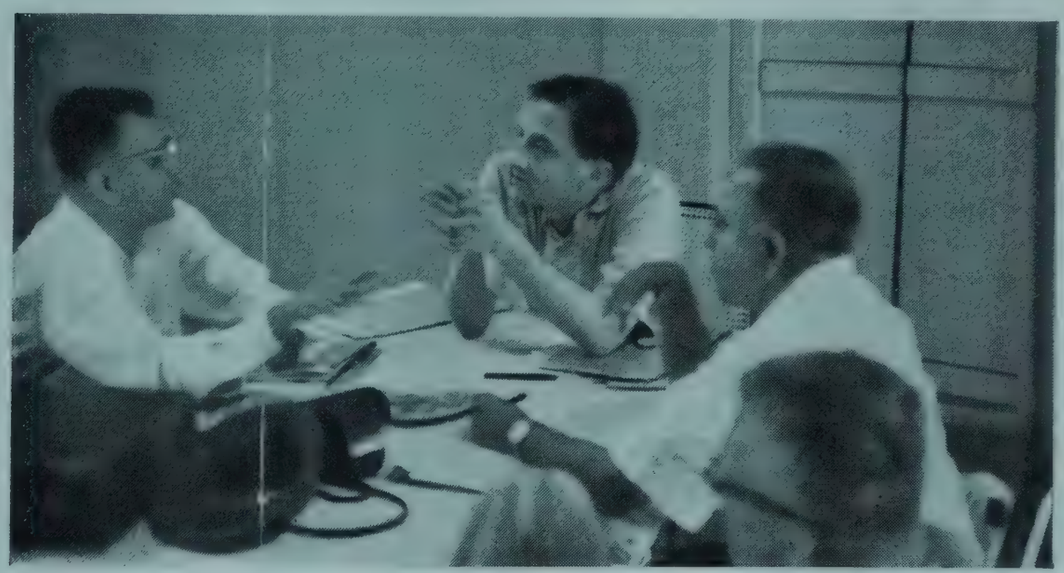


nissioning the computer TDC-12 at Trombay, 1969. In the centre is the present Chair- of AEC, Shri H. N. Sethna.

If we are to play a meaningful role ationally, and in the community of ations, we must be second to none in ne application of advanced technolo- es to the real problems of man and ociety which we find in our country."



Inside the CIRUS reactor building at Trombay. *Below.* Planning an experiment at Thumba.



the Prime Minister at the dedication of the Thumba rocket range in Feb. 1968.

At a seminar on Radiation Protection at Trombay.





On Need for Collaborative Space Effort

AT the moment, in India we are deeply interested and involved in an evaluation of the benefits that a synchronous satellite can provide for national needs of point-to-point communications, for mass communications through direct broadcast television to promote national integration as well as the economic development of isolated communities, for meteorological observations covering the vast Indian ocean and for assisting navigation. Just for one application, namely, the provision of broad-band communications for reaching, through television, half a million villages of India, it can be shown that using satellites the investment would be only about a third of what would be required with conventional technologies. Where capital funds and foreign exchange are crucial bottlenecks, the deployment of a satellite communication system based on a largely indigenous effort in electronics can make all the difference to a national decision for adopting the most effective and pursuasive means as yet available for mass communications.

One of the hardest questions to be faced in adopting a synchronous satellite for national needs, arises from the fact that many interested countries would not expect in the near future to have an independent capability for placing such a satellite in orbit. The nations advanced in space research have done much to extend the benefits of the peaceful uses of outer space to all countries, and one can reasonably count on their continued support. But the political implications of a national system dependent on foreign agencies for launching a satellite are complex. They are not negative in the present day world only in the context of the coming together of the national interests of the launcher and the user nations. As long as there is no effective mutuality or interdependence between the two, many nations left only with the ground segment would probably feel the need for some measure of redundant capability under complete national jurisdiction. There is great scope today to explore this structure of possible international systems which could provide credibility in increasing measure that the space segment could be relied upon even in the context of political and ideological differences amongst nations.



With Dr. Glenn Seaborg, former Chairman of USAEC.

Perhaps collaborative participation of nations in the construction and operation of a launching system for the peaceful uses of outer space would be realised in the long run. The military overtones of a launcher development programme of course complicate the free transmittal of know-how of technology involved in these applications. But it is important to note a fundamental aspect of human development, that knowledge cannot for long be contained within artificial boundaries and one has to learn to share and to control rather than control harmful effects through withholding transfer of technology or knowledge. After all, the biggest secret regarding the atom bomb was let out when, through the demonstration of the explosion over Hiroshima, it became known to everybody that the device worked. Similarly, the biggest secret in space research became public property when the successful orbiting of the first Soviet satellite proved that this feat was possible. Thereafter, it is merely a question of time. Restrictions on the transfer of technologies which are involved in the peaceful uses of outer space merely jeopardise the security of the world through retarding the progress of nations.

(*From speech at the U.N. Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, Aug.* 1968)

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THERE are some who question the relevance of space activities in a developing nation. To us,



Examining a sample of the moon rock.

there is no ambiguity of purpose. We do not have the fantasy of competing with the economically advanced nations in the explorations of the moon or the planets or manned space flight. But we are convinced that if we are to play a meaningful role nationally, and in the community of nations, we must be second to none in the application of advanced technologies to the real problems of man and society, which we find in our country. And we should note that the application of sophisticated technologies and methods of analysis to our problems is not to be confused with embarking on gradiose schemes, whose primary impact is for show rather than for progress measured in hard economic and social terms.

* * *

One of the most important benefits of space research lies in the spin-off which follows. I might illustrate this from the experience which we are gaining in the development of rockets. This involves new disciplines and an understanding of materials and methods; of close tolerances and testing under extremes; the development of guidance and control and the use of advanced information techniques. When one succeeds, it is through the working together of a large number of specialists who dedicate themselves to a common task. Indeed, I often feel that the discipline and the culture of the new world which emerges through the pursuit of activities of this type are amongst the most important from the standpoint of a developing nation.

A question that often arises is whether we are today in the midst of a qualitative or merely a quantitative change. I would like to suggest that with the release of the energy of the atom, the growth of electronics and man's ability to operate in outer space, 'the world' has been created. This demands a change of our values. And there is no hope for those who wish to advance step by step, following outmoded methods.

(From speech at the dedication ceremony of the Thumba Equatorial Rocket Launching Station, Feb., 2, 1968)

The Three Cultures

It is necessary in creative work to be able to see squirrels and birds. But one of the most important aspects which I would like to deal with you here is this aspect of the relationship of the culture of fundamental research, the culture of research and development and the culture of industry; for the main task of Atomic Energy Commission in this country is to provide the benefits of atomic energy for the development of the nation and, I think, it is necessary to understand that the main task is related to the completion of this entire innovative change from fundamental research to industry, if we are to succeed. I would suggest that the primary task of fundamental research is to discover; of research and development is to optimise, and of industry to produce, and one of the main problems that are faced in the organisation of innovative institutions or establishments is to make the link between these three cultures and to provide for a basis by which transfer of knowledge, of men, of technology can proceed from one step to another interacting freely and also benefitting one from the other.

(At the Silver Jubilee Celebrations of the Tata Institute of Fundamental Research, April 1971.) ●

Tributes

(Continued from page 3)

Prof. M. G. K. Menon

(Chairman, Electronics Commission, ISRO, and Director, Tata Institute of Fundamental Research, Bombay.)

Pierre Curie remarked that the object in life is "To make life a dream and to turn that dream into reality". Vikram Sarabhai had a dream of an India in which one need not have to go through the laborious time-consuming processes through which the rest of the world had advanced. He was aware that science and technology had come in a significant way to change the picture and that it would be possible for this country to leap-frog into the future if only one used science and technology in an appropriate way. This Institute is devoted to science and technology and I hope that each one of us when thinking of Vikram Sarabhai thinks of the shining vision he had, and thinks in our own way what to do to turn that into reality. It is difficult to meet a person who was more courteous, more polite, more kind, more modest, more simple than Vikram, inspite of the greatness that he achieved in the short span of life given to him. There is no question that he created for himself a unique position at the time of his death. He was indeed the colossus in Indian Science, providing the main springs of confidence that with science and technology we can transform the life in this country and its people.

Shri J. R. D. Tata

(Member, Atomic Energy Commission)

When Home Bhabha died 5½ years ago, it seemed to those of us who had been associated with him both in the Atomic Energy Commission and the TIFR, that it was almost impossible that any one could be found who would adequately carry on his great work and the programme that he had introduced. Vikram Sarabhai was the man and he rose brilliantly to the occasion. And as a member myself of the Atomic Energy Commission, I personally know how magnificiently he did his job as Chairman of the Atomic Energy Commission, as Secretary to the Government of India in the Department of Atomic Energy, as the man who took over Homi Bhabha's berth. In addition he also devoted a great deal of his time and energy and creative talent to the development of the space programme and also to continue the work of Homi Bhabha on electronics. As you probably know, Dr. Bhabha died shortly after completing the electronics report. The implementation of this report was entrusted to Dr. Vikram Sarabhai and after a few years — in fact, in recent months he was the main mover for the creation of the Electronics Commission.

One thing that again united strangely, to my mind, both Dr. Bhabha and Dr. Sarabhai is their vision of the application of science to the practical development of India for peaceful purposes, for nation building purposes. Dr. Bhabha visualised atomic energy as a great, in fact an essential, source of power for industrial and economic development of the country and also visualised many other fallouts from this great new science. Similarly, Dr. Sarabhai saw in space not merely a glamourous, exotic, exciting, new form of science — moon landing and that kind of thing, but he saw in the development of the space programme a great opportunity to harness space science to important tasks within the country, mainly in the field of communication, television, education etc.

To me he was also a personal friend. I think anybody who knew Vikram Sarabhai well and closely could not but have admired this very modest, simple, charming, soft-spoken, always courteous gentleman who was altogether a good man. ●

Scientist, Educationist...

(Continued from page 14)

poverty and regional imbalances in our country cannot be effectively tackled without it.

"Several uses of outer space can be of immense benefit to us as we strive to advance economically and socially. Indeed without them, it is difficult to see how we can hold our own in a shrinking world. The greatest cost/effectiveness of the uses of outer space occur through large scale applications rather than those of limited scope. A communication satellite can most effectively serve communities dispersed over large areas. Meteorological applications of satellites are likewise most relevant for a global system like the World Weather Watch".

"There might be many opinions concerning what would be an advantageous course to follow in the short run, but 10 or 20 years from now, when the population of India would be somewhere between 750 and 1,000 millions, it can hardly be controversial that we would need a very strong base of science and technology, of industry and agriculture, not only for our economic well-being but for our national integration and for ensuring our security in the world."

Dr. Sarabhai was an imaginative scientist who loved to work on scientific problems on the frontiers of knowledge. He was a rare combination of idealism and vision, and brought to bear his keen mind, bold imagination, and tireless energy to stimulate people to utilise modern science and advancing technology to make this earth a better place to live in. This meant research on materials, devices and systems, and the encouragement and motivation of young scientists and engineers to manage their affairs with understanding, self-reliance and responsibility. He was divinely human in his relations with men.

Vikram Sarabhai lived the life of a practical *Karma Yogi* — doing his self-allotted duties (*Swadharma*) with selfless (*Anasakta*) and tireless devotion till the moment of his final sleep.

"Scientist, Educationist, A Warm Friend"

Dr. K. R. Ramanathan, a close associate and mentor of Dr. Sarabhai for over twenty years writes this short review of Dr. Sarabhai's life and interests. Dr. Ramanathan is now in his eighties.

FROM his early years, Vikram showed keen interest in science and scientific devices. For his collegiate education, he was sent to St. John's College, Cambridge in 1937. He took his B.A. degree with Physics and Mathematics in 1940 and began to work on problems of Nuclear Physics, but the World War started and he came back to India and joined the Indian Institute of Science at Bangalore to continue his postgraduate studies under the Nobel Laureate Dr. C.V. Raman. He chose Cosmic Rays as the subject for his postgraduate research.

He personally built the necessary equipment for his experimental work and made measurements and studies at Bangalore, Poona and Apharwat in Kashmir Himalayas. In 1945, at the end of the World War he returned to Cambridge and took the Ph.D. degree of the Cambridge University with a thesis on "Cosmic Ray Investigations in Tropical Latitudes". He was awarded the degree in 1947.

Dr. Sarabhai's aptitudes and talents and the intellectual and cultural atmospheres of Cambridge, Bangalore and Ahmedabad produced in him a keen desire to create institutions in which new science and advancing technology could be nurtured and developed and used for improving the living conditions of large populations. This began to simmer in his mind even when he was doing his post-graduate work in Bangalore. In 1942-43, he was planning to start a Physical Research Laboratory at Ahmedabad. In 1945, the Sarabhai family established the "Karmakshetra Educational Foundation (KEF)" for the purposes, among others, of starting, carrying on, and helping to carry on *advanced scientific research, and educational activities of all types.*

Shortly after Dr. Sarabhai's return to India in 1947, he set about the work of starting the PRL. He enlisted the cooperation of Shri Kasturbhai Lalbhai, Shri G.V. Mavlankar and other members of the Ahmedabad Education Society and of Dr. Shanti Swarup Bhatnagar, and in November 1947, an agreement was reached between the AES and KEF to start a Physical Research Laboratory at Ahmedabad for the study of Atmospheric Physics and Cosmic Rays. I had agreed to join Dr. Sarabhai immediately after my retirement from the India Meterological Department in February 1948. The Laboratory started with a couple of Research Assistants, a small office, a small workshop and a few research scholars. We were able to get support for our work from the Council of Scientific and Industries Research and the Ministry of Education and from the Department of Atomic Energy. We were temporarily housed in a few rooms in the M.G. Science Institute of the Ahmedabad Education Society.

The over-all programme of the laboratory as chalked out by us in 1948 was to make an integrated study of the different radiations which reach the earth from the sun, stars and space and their geophysical consequences. The necessity was felt to provide for studies in theoretical physics, radio physics and electronics and also for a separate properly planned research laboratory. With the sympathetic assistance of the then Ministry of Natural Resources and Scientific Research and the Atomic Energy Commission, and land and funds found by AES and KEF it was possible to go ahead with the construction of the laboratory, and the foundation stone of the new laboratory building was laid by Dr. C. V. Raman in February 1952. The Laboratory was opened by Shri Jawaharlal Nehru in April 1954.

An important additional aim of the Laboratory has been to serve as a post-graduate study centre for physics in Western India and to train research students in experimental and theoretical physics. The Laboratory does not take any fees from research scholars and most of them receive scholarships or fellowships.

Dr. Sarabhai's range of interests had always been wide and he had an integrating mind with an eye towards the future. Between 1947 and 1955, besides the Physical Research Laboratory, Dr. Sarabhai was mainly responsible for the creation of two other Institutions in Ahmedabad which have proved to be of all-India importance. These are the ATIRA, (the Ahmedabad Textile Industry's Research Association) an organisation also started in 1947 with support from the industry and the Council of Scientific and Industrial Research, and the Indian Institute of Management which was started in 1955. Of both these Institutions, he was the first Hon. Director who nurtured them in their early formative years until competent full-time Directors could be appointed.

A new responsibility came to Dr. Sarabhai when, in 1961, he succeeded the late Dr. K. S. Krishnan as a member of the Atomic Energy Commission. By that time, the use of earth satellites for exploring particles and fields in the earth's exosphere, magnetosphere, and in interplanetary space had become well established. With his active interest in Cosmic Rays and the Upper Atmosphere, and with the awareness that India was an important area in which space exploration by rockets and satellites would be of great long-term value to science, and in which bright young Indian scientists with fresh minds could develop new techniques and evolve new ideas, Dr. Sarabhai and

(Continued on next page)

Dr. Bhabha decided that it was a field to whose cultivation the Department of Atomic Energy should give full support. The expansion of the PRL, the organization of INCOSPAR (Indian National Committee for Space Research), the establishment of the Rocket Launching Station at Thumba very close to the magnetic equator, followed by its recognition by UN as an international Equatorial Rocket Launching Station, and the growth of the Space Science and Technology Centre at Thumba were the outcome of the creative efforts of Dr. Sarabhai fully supported by Dr. Bhabha, Pandit Jawaharlal Nehru and Smt. Indira Gandhi.

Dr. Sarabhai visualised from the very beginning the potential value of space science and space technology for national development and for promotion of international peace.

In 1966, after the tragic death of Dr. Homi Bhabha, Dr. Sarabhai was asked to take up the Chairmanship of the Atomic Energy Commission and his work increased manyfold. He threw himself whole-heartedly into the work with boundless energy and brought the activities of the Department of Atomic Energy and Space Research Organisation (ISRO) into even closer contact. This has resulted in the development of SSTC (Space Science and Technology Centre) at Thumba, of the rocket and potential satellite launching range at Sriharikota on the Pulicat Lake north of Madras, of the Experimental Satellite Communication Station at Ahmedabad and the construction of the Overseas Satellite Communication Centre at Arvi in Maharashtra.

A problem to which Dr. Sarabhai gave much thought was the use of earth stationary satellites for mass education through television in large developing countries like India where problems of population growth, agricultural productivity and removal of illiteracy loom large. He created a Study Group on Satellite Instructional Television Experiment (SITE) to consider what would be the best means of achieving this. The SITE in consultation with NASA scientists has proposed a pilot project using a geostationary satellite ATS (F or G) to be launched by NASA and located over the Indian Ocean. The project will involve using the Experimental Satellite Station at Ahmedabad (ESCES) for transmitting well-planned TV programmes to the ATS satellite (which will be at a height of 37,000 km) and receiving them either directly with appropriate television receivers or through three VHF re-broadcast stations at Ahmedabad, Delhi and one other station. The required 5,000 television community receivers will be manufactured in India and the ground stations set up by Indians. If the pilot plant proves successful, Dr. Sarabhai contemplated putting up in due course (1980-85) geo-stationary satellites from Sriharikota. This is a bold, ambitious project, which he believed was within the country's capability.

Another example of Vikram's imaginative approach to national educational problems was the establishment of a "Community Science Centre" at Ahmedabad under the auspices of the "Nehru Foundation for Development" — founded by himself, his mother and other members of his family. It has received encouragement and support from the Ahmedabad Education Society, the Government of Gujarat, the University Grants Commission and the Ministry of Education of the Government of India. A modern building for the Centre has been constructed in the campus of the Ahmedabad Education Society near the University. It provides laboratory, library and workshop facilities for young school and college boys and girls to learn, ask questions and do experiments under the supervision of qualified scientists. It also holds seminars for teachers and organizes scientific exhibitions and prepares science text-books.

In the midst of his heavy administrative duties, Dr. Sarabhai managed to squeeze time to do important scientific work in the field of Cosmic Rays and their temporal and spatial variations and their relation to geomagnetism, solar activity and interplanetary space. Between 1949 and 1971, 20 post graduate scholars working under him have taken their doctorate degrees and about 50 scientific papers have been published by him in international scientific journals, many of them in collaboration with his students. The work of Dr. Sarabhai and his students has demonstrated the importance of Cosmic Rays as an invaluable tool for investigating the changes in interplanetary space due to the emission of radiations from the Sun.

Dr. Sarabhai received many honours both in India and abroad. He was the president of the Physics Section of the Indian Science Congress in Cuttack in 1962 and of the Indian Geophysical Union 1970-71. He was the recipient of the Shanti Swarup Bhatnagar Medal (1962) and the Padma Bhushan Award from the President (1966). The Padma Vibhushan was awarded to him posthumously this year.

He was a member of the International Council of Scientific Unions (1966), Chairman of the Panel of Experts and Scientific Chairman of the UN Conference on the Exploration and Peaceful Uses of Outer Space (1968), President, 14th General Conference, International Atomic Energy Agency. Vienna (1970), and Vice-president, Fourth UN Conference on the Peaceful uses of Atomic Energy (1971).

In a recent note on "Atomic Energy and Space Research — a Profile for the Decade 1970-80", Dr. Sarabhai summarised his views as follows :

> "Nuclear power is today essential for economically supplying energy in large parts of the country, and is moreover the only major supply on which we will need to fall back in perhaps less than 50 years time. We, therefore, need to commit ourselves to an appropriate programme of atomic power stations. We cannot hope to gain all the great economic advantages of nuclear power unless we develop a mix of thermal and advanced fast breeder reactors. It is my firm belief that the problems of

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Some Editorial Tributes

VIKRAM Sarabhai was the great consolidator who built soundly on the foundations laid by his predecessor. The development of atomic energy made rapid progress under his stewardship and guidance, and he gave the country a start in space technology. India has now reached a stage where it can go nuclear in the defence field if it wishes to do so. Like Homi Bhabha before him, Vikram Sarabhai helped India signally to achieve this impressive capacity.

With all his numerous and varied achievements, and like truly great minds, Vikram Sarabhai was a disarmingly modest and unassuming man. He has passed away not in the fullness of years but in the prime of his life.

— *The Indian Express*

DEATH came too soon to Vikram Sarabhai when he was still relatively young and productive and the nation had need of him. He has been plucked away, like Homi Bhabha whom he succeeded, just as new fields were opening up as a result of his ideas and exertions. If Bhabha laid a sound theoritical and practical basis for India's nuclear development in building up the Tata Institute of Fundamental Research, the Atomic Energy Establishment and the nuclear power programme, Vikram Sarabhai carried this work forward, further diversified and expanded it, and was largely responsible for developing the country's fast growing space effort. It was fitting that if he had to die in harness the end should have come in the course of a visit to Thumba, the home of the Space Science and Technology Centre and the Thumba Equatorial Rocket Launching Station. Only a year ago, Sarabhai presented to the Government and persuaded it to adopt a ten-year perspective programme of nuclear and space development for whose implementation he worked unsparingly.

Like Bhabha, Sarabhai thought big. If this sometimes seemed a fault, it was the failing of a dynamic spirit impatient for great things. An Indian space satellite, a national satellite-terrestrial television network as an aid to development, and agro-industrial complexes based on nuclear-powered energy centres are among the concepts he passionately advanced. He combined the best of being modern and "Indian", blended aesthetics with science, and consistently canvassed the true role of the administrator as an innovator rather than as a conservator. A scientist of standing and a creative mind, Vikram Sarabhai's memory will live by his many accomplishments, the programmes he initiated and supported, and the men he trained and inspired.

— *The Hindustan Times*

IN the untimely death of Dr. Sarabhai, Indian science has lost one of its most dedicated leaders. Having inherited Dr. Bhabha's mantle at a crucial stage in the country's atomic energy programme, he not only carried out the tasks in hand with vigour but also extended the nation's scientific effort to new frontiers. The many establishments in the country devoted to various facets of space research and the Electronics Commission bear witness to his unremitting work. A man of diverse interests — photography, archaeology and fine arts, among them — he believed that a scientist should never shut himself up in an ivory tower or ignore the real problems of society in pursuit of "pure" knowledge. It was his lively awareness of the scientist's obligations to the community that prompted him to float projects for the utilisation of television as an aid to agricultural extension, family planning and mass education in the rural areas. In the same spirit, he devoted a good deal of his time to the problems of unemployment relief and management of science and reversing the so-called brain-drain, though in some of these areas he could not give a concrete shape to his ideas.

— *The Times of India*

ONE of Dr. Sarabhai's achievements was the preparation of a perspective plan for nuclear power development and space research. Though its central objective was to develop nuclear energy for peaceful purposes, at the same time the pursuit of the path charted by him left the country room to exercise a nuclear option in the future if the country's security arrangements warranted such a course.

It will be, however, wrong to associate Dr. Sarabhai only with atomic energy and space research. He was in fact more interested in the application of science to society than on mere modalities like provision of cheap electricity. "Scientific thought, approach and methodology," he once said, "have a potential for making contributions to society of far greater significance than tangible results of technology in terms of products and services, staggering as they are. We have today a very sizable educated professional group which is largely passive in relation to the tasks of development. Its active participation and the commitment of local initiative in each area are, in my opinion, necessary conditions for social progress, political stability and integrity of the nation". That perhaps sums up the basic philosophy of Dr. Sarabhai. Urbane and versatile, apart from his basic interest in science, he was also a lover of music and the fine arts. The void left in the world of science by his passing will indeed be difficult to fill.

— *The Economic Times*

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 1, and printed by him at Conway Printers Pvt. Ltd., 167c, Dr. A. B. Road, Worli, Bombay 18.

Registered No. R. N. 9002/62



NUCLEAR INDIA

VOL. 10 NO. 6 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY FEBRUARY 1972

Shri Sethna Takes Over as Chairman AEC

SHRI H. N. SETHNA, 48, Director of the Bhabha Atomic Research Centre (BARC), Trombay assumed office as Secretary to the Government of India in the Department of Atomic Energy and Chairman of the Atomic Energy Commission on January 22. Shri Sethna continues as Director of BARC.

The new Chairman of the Commission brings to his position a rich technical and administrative experience in atomic energy. He has been with the Atomic Energy Commission since 1949 when he first took up a position with the Indian Rare Earths Ltd., a public sector undertaking administratively responsible to the AEC. In 1959 Shri Sethna joined the then Atomic Energy Establishment (now known as the Bhabha Atomic Research Centre), and later became the Director of the Engineering Group of the Centre. On the demise of Dr. Bhabha in 1966, Shri Sethna was appointed Director of the Bhabha Atomic Research Centre, and Member for Research and Development in the Atomic Energy Commission.

Indigenous Know-how

Shri Sethna has made significant contributions to the atomic energy programme. Under his leadership a number of sophisticated plants required for implementing the programme were set up speedily and without foreign collaboration. Shri Sethna had the full technical responsibility for building a plant at Alwaye in Kerala for separating rare earths from the monazite-rich beach sands of that State. This step marks the beginning in the exploration of India's resources of nuclear raw materials. As a sequel to this accomplishment, Shri Sethna built a thorium plant and a plant for the production of nuclear grade uranium metal at Trombay. These plants form the base for the processing of naturally occuring fissile and fertile material. It may be noted that data for many of the processes involved and the required technical know-how were not forthcoming from countries advanced in these areas and they had therefore to be developed indigenously.

In August 1964, the Plutonium Plant was completed at Trombay. This remote-controlled, highly instrumented plant was designed and constructed entirely by Indian scientists and engineers working under Shri Sethna who was the Project Engineer. Concurrently with work on the Pluto-

(Continued on page 2)



Prof. Menon Is Chairman ISRO

PROF. M.G.K. MENON, Director of the Tata Institute of Fundamental Research, Bombay, and Chairman of the Electronics Commission, took over as Chairman of the Indian Space Research Organization on January 22. He continues to hold his responsibilities in TIFR and in the Electronics Commission.

Prof. Menon, 43, is known for his work in the area of cosmic ray research where he has achieved international recognition. He was awarded the Shanti Swarup Bhatnagar Memorial Award for 1960 for his outstanding contributions to the physical sciences. He was honoured with the Padma Shri in 1961 and Padma Bhushan in 1968. Prof. Menon was elected Fellow of the Royal Society, London in March 1970. He is a Vice President of the Indian Academy of Sciences, and Fellow of the Indian National Science Academy. In February 1971, he was appointed Chairman of the newly set up Elec-

(Continued on page 2)



Significant Contributions to Nuclear Programme

(Continued from page 1)

nium Plant, the construction of a uranium mill was taken up at Jaduguda under his guidance, and completed in 1967. During the years 1956-58 Shri Sethna was also the Project Manager for the construction of the 40 megawatt CIRUS research reactor at Trombay.

Between June 1967—May 1971 Shri Sethna also held the position of Director of the Power Projects Engineering Division of DAE, which is responsible for constructing the Rajasthan Atomic Power Station and the Madras Atomic Power Station.

Besides his association with the Department of Atomic Energy, Shri Sethna has been intimately involved with other national and international agencies. He was Deputy Secretary-General to the UN International Conference on the Peaceful Uses of Atomic Energy held in Geneva in 1958; Member of the UN Secretary General's Committee of Specialists for preparing a report on all possible contributions of nuclear technology to the economic and scientific advancement of developing countries; Member of the Committee on Science and Technology to the Cabinet, and of the Board of Directors of the Indian Rare Earths Ltd. and the Electronics Corporation of India Ltd.

The Chairman's outstanding contribution to the country's atomic energy programme has been nationally recognized. He is a recipient of the Padma Shri (1959), the Shanti Swarup Bhatnagar Memorial Award, (1960) and the Padma Bhushan in 1966. Shri Sethna also received the Sesquicentennial Award of the University of Michigan in 1967 for "Knowledge, Wisdom and Courage to Serve". ●

Charged Particles

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ber of large bubbles decreased as the freezing temperature was lowered. But at any freezing temperature the particles frozen in the air stream had bigger cores and fewer large bubbles.

The water used in the experiments was similar to rain water, whose main impurity is absorbed carbon dioxide. If common salt was added to make it correspond to natural cloud water, electrification was only halved. So the Durham scientists say it is reasonable to expect that the results they obtained apply to the freezing and melting of water in the atmosphere.

But they also say that a particle can be formed in layers, because of different freezing rates. When these layers melt they can contribute to the particle's charge to different extents and at times may even reverse the charge's sign. This could explain one of the mysteries of clouds — the positive and negative charges both found in particles. (SPECTRUM 1971/90) ●

Prof. Menon's Research Accomplishments

(Continued from page 1)

tronics Commission and Secretary to the Government of India in the Department of Electronics. Prof. Menon is one of the two Foreign Honorary Members from India of the American Academy of Arts and Sciences.

Prof. Menon had his education at the Jaswant College, Jodhpur, the Royal Institute of Science, Bombay, and the H.H. Wills Physical Laboratory, University of Bristol, England. He obtained his Ph.D. from Bristol in 1952. At Bristol he worked with the well-known Nobel Laureate Prof. C.F. Powell, F.R.S.. During his stay in Europe he was associated with Professors D.H. Perkins, F.R.S., P.H. Fowler, F.R.S., G. Occhialini of Italy and C.O'Ceallaigh of Eire.

Research Work

During 1952-53, he was a Research Associate at the University of Bristol. He also held the Senior Award of the Royal Commission for the Exhibition of 1851 from 1953 to 1955; the only other Indian to hold this Award before him was the late Dr. H.J. Bhabha. In 1955, he joined the Tata Institute of Fundamental Research, Bombay as Reader and became three years later an Associate Professor. In 1960, he was made Professor and Dean of the Physics Faculty, and rose to the position of Senior Professor and Deputy Director (Physics) in 1964. He was appointed Director of the Institute in February 1966.

The principal research contributions of Professor Menon have been in the area of nuclear emulsion and balloon flight techniques; elementary particle physics, particularly relating to strange particles; and cosmic ray investigations in India at high altitudes and at great depths underground, at the Kolar Gold Fields. He has published about sixty papers on these topics, in collaboration with colleagues at the Tata Institute of Fundamental Research, and abroad. These papers have brought out the following aspects of scientific value and interest: demonstration of the existence of muons of varying energies, of monoenergetic high energy pions, and of electrons of varying energies, as secondaries in the decays of heavy mesons, (the K-particles), thus establishing the $K\mu_3 K\pi_2$ and Ke_3 decay modes; first demonstration and discussion of scattering phenomena involving K-mesons; extension of emulsion work to very large stacks; the technology of fabricating and flying balloons with volumes upto several million cubic feet under tropical conditions, particularly through the very low temperatures of the equatorial tropopause; the use of counter telescopes of various types, including the use of high pressure gas Cerenkov counters for primary cosmic ray studies; demonstration of the great possibilities inherent in observations at great depths below ground for investigations involving natural neutrinos of very high energy and first clear observations of cosmic ray high energy neutrino interactions; investigations concerning muons at very high energies. ●

AMCHITKA

On November 6, the United States set off its biggest underground explosion of an atomic device at about 5875 feet (about 1800 m.) under the surface of Amchitka Island in the Aloutian Chain of Alaska. While the collection of details, data and its analysis will take time, the USAEC has released some information on the effect of the test on the environment and life around the site which is of interest. What follows is a summary of some of the observations after the test.

Radioactivity

There has been no detectable release of radioactivity to the marine or surface environment as a result of the Cannikin site explosion. Measurements will continue for a number of years.

Seismicity

No large earthquake was triggered by the detonation, although hundreds of aftershocks much smaller in recorded magnitude than the shock wave from the explosion were registered in the vicinity until collapse to the surface of the cavity created by the detonation. This occurred about 38 hours after the test. These small aftershocks were no longer observable after cavity collapse. A preliminary survey of the surface subsidence indicates it has a maximum depth of about 60 feet, with a radius of approximately 2,600 feet.

When surface collapse occurred, seismic instruments at Palmer, Alaska, recorded the resulting earth disturbance as having a Richter magnitude (surface wave) of about 5.0.

Ground motion resulting directly from the detonation was felt strongly on Amchitka, distinctly at Adak, nearly 200 miles away, and less distinctly at Shemya, somewhat farther away. There is no record of perception at greater distance than these two U. S. military installations.

Sea Waves

Natural ocean wave activity was high in the Amchitka region when Cannikin was fired because of very strong winds the previous day. No tsunami, or large ocean wave produced by ocean floor movement, was observed or recorded.

Surface Effects

The tundra surface in the ground zero area was considerably cracked and otherwise disturbed, as had been expected. Two ponds in the area were drained and three others partially drained. Cliff and turf falls along the Bering Sea for a two-mile stretch near ground zero were greater than had been predicted, and preliminary indications are that the beach and ocean floor in the near vicinity of the Cannikin site has been lifted permanently by several feet.

Cliff and turf falls along the Pacific Ocean side of the island appeared to be approximately as predicted.

The dike of a pond holding drilling mud, about 4.7 miles from ground zero, developed cracks from Cannikin ground motion, and an estimated 5,000 cubic yards of drilling mud escaped before the cracks were sealed. Most of the mud flowed into a small creek that empties into the Pacific Ocean, with the inflow being at a point about one and a half miles from the ocean. On the basis of other experience it must be assumed that organisms in the affected portion of the creek were destroyed, and that life will return to that part of the stream within a few years.

Environmental Effects- Living Things

Since Cannikin, numerous surveys have been made, and are continuing, in an attempt to record its effects on and near the island. No effects at greater distance have been observed.

At this time, observed effects on species of living things on and near Amchitka indicate that no permanent harm will result from the test to any population of mammals, birds, fish, other marine life, or plant life. To date, searches of the sea shores of Amchitka have located 14 dead sea otters, and all these bodies were recovered. Two additional injured otters were observed from helicopters, but the bodies were not recovered. Another two abandoned small otter pups were seen and not recovered. It is assumed that all these died, making a total of 18, of which 16 were on the Pacific side and two on the Bering side. It is not believed likely that more explosion-injured sea otters will be found.

Of the 14 recovered sea otter bodies, 12 underwent autopsies. Deaths of seven appeared to be from overpressure in water, two died from rockfalls, and three apparently were fatally injured by vertical acceleration (upthrust of the ground)

Aerial counts have indicated a lessened number of sea otters in the Bering Sea near the Cannikin site as compared with their number before the test. The water there is muddied for some distance because of siltation from turf falls into the water. On the Pacific Ocean side of Amchitka and along other parts of the Bering coast it appeared that normal numbers of sea otters were observed.

Four dead seals were found in the sweeps, and all were autopsied. All apparently died from overpressure. A survey, November 18, of Seal Beach on the Pacific side of the island showed a normal number of seals (about 75) on the beach.

Hundreds of dead fish were found on beaches, most of them greenling which live around the kelp beds fringing Amchitka. A scuba survey of ocean bottom areas near ground zero on both the Pacific and Bering sides of the island indicated no significant difference in numbers of sea urchins from their number before the test. Sea urchins are believed to be a significant portion of the diet of sea otters.

Autopsies of 16 dead birds found on the island indicated that all but one died of the effects of the explosion, seven from overpressure and eight from vertical acceleration. No eagles or peregrine falcons were among the dead birds.

Three or four bald eagle nesting sites along the Bering coast and two

(Continued on page 8)

Nuclear Power P

THE climate in India for industrial activity has changed dramatically in the last few weeks. There is a spirit of optimism, a realisation, that the only way we can really advance, is the hard way, by doing things ourselves and by being rather choosy in the type of assistance and aid we would accept. The decline in the quantum of aid is, to my way of thinking, a golden opportunity for the country to develop fully its latent capacity, and give a strong impetus to our scientists and engineers to show their mettle. To organisations like ours, it arouses a greater sense of purpose not only in our own fields of specialization but also the fallout from this type of a total Research & Development activity.

In these changed circumstances, it is but natural that one looks at all R & D activities and analyses their usefulness to the community and to the economic advancement of the country.

One of the most important *raison d'etre* for research and development in the field of atomic energy, in fact the most important one, is its application to the generation of power. It is universally accepted that per capita energy consumption is the single most important indicator of the standard of living of a country. India consumes or rather produces some 75—80 K Watts per capita of power. Of this, some 6.5 K Watts are available for uses other than industrial.

Reduce Dependence

Energy production in India is from two main sources — the conventional *i.e.* the commercial sources which consist of fossil fuels, hydro power and nuclear power and the non-conventional *i.e.* non-commercial like firewood, dung and wastes. This non-conventional portion in 1969 accounted for more than 50 per cent of the total energy consumption in the country with dung contributing about 5 per cent, firewood 38 per cent and vegetable wastes about 9%*. We have, therefore, to reduce our dependence on the non-conventional types of sources as these could be better utilised for increasing our output of other goods, especially agricultural products.

If we are to reach any level of prosperity we should be consuming between 200—300 K Watts per capita. It can therefore be seen that it would be impossible to meet India's requirements of energy on a long term basis from our fossil and hydro resources. We have therefore to turn to other sources, and nuclear energy seems to be the most economical solution on a long term basis.

Social Parameters

The introduction of this new technology in a developing country usually gives rise to many problems. These are problems essentially of compatibility. New technologies — and nuclear technology is no exception — are usually the extensions and perfections of existing technologies. However, if there is only a small base of conventional technology, this process of extension and perfection assumes difficult proportions. The difficulties become more pronounced if we blindly accept social, economic and technological parameters as existing in advanced countries.

I have brought in social parameters because they are a very important factor in directing technological and economic policy as they lay down priorities and the general pattern and method of achieving our goals.

It would be very convenient to have a car for every family in the country, but should not one aim at better housing, better nutrition and better health? In short, our social priorities should be tailored to our own conditions and the basic structure of society we are aiming at. These priorities then dictate our requirements of technology and hence the necessary funding *i.e.* economics. I have merely chosen cars as an example but one can go down or up the line and come to rather an interesting set of dilemmas our planhers have to face in determining priorities and the inter-relationship of these priorities with technologies which have to be developed or imported and the necessary industrial infrastructure which has to be built up.

When one looks at the question of nuclear power, the set of dilemmas I mentioned earlier show up in a very prominent manner. In determining the type and size of nuclear power stations, one is confronted with a variety of questions which have to be answered after a deep analysis of all factors. Even these analyses have to be updated constantly as nuclear power is completely dependent on

By H. N. Sethna
Chairman, Atomic Energy Commission

industry for the supply of its requirements, and for the manufacture of various components. Another factor is the ability of our transportation system to handle large and heavy pieces, some of them weighing more than one hundred tonnes.

Another problem would be the compatibility of a unit size which could fit in a grid with safety. Nuclear power stations in India which have been completed or are under construction, have a limit size of approximately 200 MW. In the industrially advanced countries, sizes of 500 MW and above are common and some even larger than 1000 MW are under construction.

Economy of Size

As far as India is concerned, the 200 MW Nuclear Unit is the largest single unit size and this is bigger than any thermal station operating at present. Should we then go in for bigger units? It is true that the cost of power is lower for large units than for small units, but this economy is possible

*Talk on Feb. 3, 1972 at the Nuclear Physics and Solid State Physics Symposium organised by the Dept. of Atomic Energy at Trombay.

**Figures from paper by Manas Chaterjee of Planning Commission, based on data from National Sample Survey.

n in Perspective*

only if there is a big enough base load so that large units can function at say 80 per cent of their rated capacity. Cycling of large units *i.e.* changing loads, is not advisable in large units as they lead to problems of maintenance. Given these limitations one has to decide on unit sizes, whether they should be of 200 MW each or larger, say 500 MW.

ANOTHER important factor which enters into the choice is the question of repetition of unit sizes. The greater the number of units of a particular size, the greater the economy in design, fabrication and erection. Upto now, the design of reactor systems was based on imported know-how. Tarapur, our first station was a turn-key job; Rajasthan the second station is of Canadian design. It is only for our third station, Kalpakkam, that the design is Indian though based on imported Canadian know-how. There have been some modifications in design at Kalpakkam but one cannot yet call it really an Indian design. When we base a design on imported know-how, we also tend to include in such a design that country's industrial infrastructure and other capabilities. This can, and usually does lead to problems. The only way of overcoming this problem is to go in for a redesign which corresponds to our own capabilities and conditions. Such a redesign involves Research and Development but pays handsome dividends in the long run. I feel that we have come to a stage in India when we should redesign the Rajasthan type of reactor to suit Indian conditions and I am certain that it would give us a more economic and efficient 200 MW unit. The redesign would of course involve R and D problems but Trombay is well equipped and suited to handle them. I am sure that the Bhabha Atomic Research Centre with its large resources of skilled manpower, expertise and above all the will to excel, will meet these challenges in a most effective manner.

As far as our choice of reactor is concerned, we have decided to go in for the natural uranium system. Even though this system is more capital intensive, with a long lead time, we had to make this choice due to the uranium position in the country.

Whilst enriched uranium systems are not as capital-intensive, they call for the import of enriched uranium, which could be cut off. If, however, we decide to manufacture enriched uranium in this country, (and we are investigating this problem) we are faced with the question of energy and costs. All methods of separation of uranium *i.e.* enrichment, involve large consumption of energy. Whilst the classical diffusion plants consume some thousands of megawatts of power, even the smaller separation plants based on ultra centrifuges, which are being planned, would consume some tens of megawatts.

The power consumption for centrifuge plants has been reported to be as low as 400 KW hrs. per kg of separative work as against about 3000 KW hrs for conventional diffusion plants. However, one must realise that even a small plant using centrifuges, handling say 100 tonnes of feed per year, would use something like 30,000 centrifuges. These machines would have to run continuously and there is no data on their reliability. It is, therefore, difficult to determine the possible costs of separating uranium by this process till more data is available. As I said, we are working on this method of separation, but it will be some time before we get the answers which would permit us to take a decision.

No Alternative

From our point of view, the centrifuge, if successful, seems to be the only way to have our own enriched uranium. One can ask — what then is the position of India? We have limited resources of uranium in ores with rather low uranium content. This makes our uranium expensive — in fact our uranium is about twice as expensive as uranium from say Canada. There is, however no alternative but to produce our own, as sales of uranium are governed by the terms of the Non-Proliferation Treaty to which we are not a signatory.

THERE is criticism that our investments in heavy engineering are not yielding the desired results. I do not agree with these critics on the causes of this problem. We have seen from our own experience that it is possible to persuade industry, especially the public sector industries, to do special jobs. The main problem is one of sustaining this effort and creating necessary organisational conditions and confidence to permit them to play an effective role. The heavy engineering complex at Ranchi, which has helped us in the VEC Project, will have to play a much bigger role and, I am sure, that it will do so for all our present and future projects. People seem to forget that in industrially advanced countries, plants like those at Ranchi, Rourkela, Bhopal, to name a few, have been the result of growth over decades. There has been time to develop the necessary managerial and technical skills whilst in India we have to compress this period into a few short years. All these efforts have to be backed by a conscious effort to improve and innovate and above all to insist or even make it a dogma that even if it takes longer to design and build in India, the experience thus gained has no substitute to progress, definitely not imported know-how or imported experts. I do not say that we should import nothing but I do say that we should utilise our investments, both physical and human, to the maximum possible extent and it is only by doing this that we can have goods and services which we can export and be thus able to import our other requirements.

AT Trombay there are other aspects of nuclear energy we work on. For instance, we are in the process

(Continued on next page)



Production of radioisotopes at the Bhabha Atomic Research Centre, Trombay.

(Continued from page 5)

of putting up an irradiator for sterilization of medical products. It is expected that the plant will be ready by the end of next year and will be able to handle 3,00,000 cubic metres of medical products like sutures, bandages, disposable syringes etc. a year. This method of sterilization, I am sure, will grow at a very rapid rate and we are already considering other locations in India for such plants.

In this field, we have received the fullest cooperation from the Drug Controller, Government of India and the Commissioner for Foods and Drugs, Government of Maharashtra. We are indeed thankful to them for all the assistance they have given us and we look forward to a continued association in allied fields.

We have been working at Trombay on the preservation of potatoes and onions using irradiation. Experiments on small batches have been successful, especially onions where we have had the full cooperation of the Nasik District Onion Growers Cooperative. As soon as we have obtained clearances from appropriate ministries, we intend to set up a pilot plant in the Nasik area for onions. We are also looking for a suitable location for a plant to irradiate potatoes; it will be located probably in the eastern part of the country where potatoes are grown in large quantities.

Expertise at Trombay

The ability of any R & D organisation to make a meaningful contribution to the country's economy is dependent on the cooperation it secures from other institutions and various industries. At Trombay we have been indeed very fortunate; we have more problems thrown at us than we can handle. An R & D organisation working in any particular field usually develops expertise in a number of allied fields. This is especially the case in India where due to the existing conditions many laboratories have created expertise not only in their own fields but also in fields somewhat removed from their own. We have a strength of about 10,000 persons and we are unable to expand because we have problems of looking after our people in the way we would like to.

Trombay carries out R & D for a number of Government organisations and certain number of industries. This arose out of necessity. Our electronics effort was started as we were unable to obtain our requirements of electronic equipment from Indian manufacturers. Our Electronics Division from rather small beginnings grew and gave rise to an electronics production division which became the base for the Electronics Corporation of India located at Hyderabad. The Uranium Corporation of India located at Jaduguda in Bihar was also the result of our R & D in the extraction of uranium from indigenous ores. I am citing these two examples as they grew out of a need of our programme and one of them, the Electronics Corporation also supplies equipment to other institutions and industries.

However, we have also developed other types of know-how where the main consumer is not atomic energy, but industry. For instance, about two years ago due to foreign exchange difficulties we could not import absolute filters which we use in our work and in our power stations. We have not only developed these filters, but in cooperation with the Forest Research Institute at Dehra Dun, have also developed the filter media. We hope to pass this know-how on to industry very shortly. In passing on this know-how we want to be assured that industry will maintain quality control which is essential because among the largest users will be the pharmaceutical industry and the electronics industry. This know-how has led us into the field of design of sterile rooms, one of which is located in this Centre. One can cite many examples where our R & D has had a fallout in other areas.

I HAD mentioned earlier that we do not wish to expand Trombay. We would however like to help industry and government organisations by solving their problems and developing local know-how. To meet these diametrically opposite requirements we are considering arrangements whereby other institutions and organisations can send their men to Trombay to work on mutually acceptable problems. We would thus be able to get over our problem of manpower and at the same time help industry. We intend to

onsibilities

take it up in a limited way very shortly and watch how it develops. Another advantage will be the availability of trained manpower for the particular industry which will go along with the know-how thereby solving the problem of technology transfer. These changes in working are likely to take some time as priorities will have to be determined, terms and conditions worked out and, above all, manpower and equipment allotted.

Technology Transfer

Our experience in the transfer of know-how for large scale production has been satisfactory so far. Our technology transfer upto the present has been within the family except for very small items. I say within the family because the companies and organisations which use this knowhow are under our control. The challenge will come when we transfer it to outside parties, *i.e.* where we have no organisational control over them. I am sure that with proper handling, this will also be successful. There will be problems but I am sure we will be able to solve them.

For this type of technology transfer one needs an efficient and forward looking R & D organisation. What then is the prescription for such an organisation?

The most important prerequisite is dedicated willing workers with a common objective, willing to accept new ideas and not be confined to their own field of specialisation. It is necessary not to build super laboratories or experimental facilities till proper teams have been formed under competent leaders. For nothing is so frustrating when starting an R & D organisation having a laboratory already equipped by someone who has no idea of the future of the organisation, and having a building which is so expensive that you cannot tear it down.

Coordination

Having got a group together the next most important criteria is coordination. We look at coordination as something which has to be done at the highest level. This is an archaic idea. Coordination should exist at every level. If not, the person at the top could get bogged down in very petty matters with disastrous results to the organisation. It is therefore advantagous to start with small groups which can be subdivided into groups as the variety of expertise increases, rather than start off with a large number of persons right at the beginning; you may end up carrying so much dead-wood that the organisation will sink.

I do not think it is possible to lay down a long-term plan on how to build up an R & D organisation. An R & D organisation is a living thing and has to change with time and any very long term planning makes it inflexible and hence ineffective. Growth plans have to change, have to be modified, in the light of experience and also in the shift of emphasis on problems facing the country. The worth of an R & D organisation is in its inherent ability to accept challenges and changes and react to them in the most efficient manner without breaking its stride.

In R & D matters it is best to avoid over-centralisation. Instead there should be a continuous feed back of information between groups of various disciplines and between those who solve problems and those who pose them and this interchange should be at all levels. To ensure this there must be a substantial delegation of powers with the head of the organisation retaining the absolute minimum and the research worker having enough or better or more than enough powers to permit him do his work efficiently and in a pleasant atmosphere.

An organisation like the Atomic Energy Commission, and there are others in the country, cannot work and produce results unless there is complete cooperation and trust between its different agencies. All agencies have tasks which are inter-dependent and unless there is free flow of information an organisation cannot survive. There is very little an R & D scientist can do unless he has feedback from the designer and the designer can never improve unless there is a similar dialogue existing between him and the fabricator: and the fabricator will never improve unless he has similar information from the user. It is such a chain which has to be forged. Each discipline giving its best and leaving mundane petty problems to others.

(Continued on page 8)

Trombay-produced radiography camera in use.



Clouds of Charged Particles

HOW do clouds become electrically charged? There are a number of explanations of what must be a highly complicated process, involving many effects, such as thermoelectric effect in ice, induction charging from the collision of polarised particles, ion diffusion and so on. Reports have been made of positive charges being acquired by melting ice with air in it meeting an air stream which carries away negative charges released when the trapped bubbles burst. Melting may be specially important and account for the positive charge detected near the bottom of thunderclouds. Some new light has been thrown on electrification by melting by two research workers at Durham University in England.

They made ice particles about 3 mm across from drops of deionized water, some by freezing in still air, others by freezing in an upflowing airstream. Then they allowed the frozen particles to melt, one by one, supported by a platinum wire in a wind tunnel in an airstream at a speed close to the particle's terminal falling speed. In effect, the particle was falling through a cloud and as it fell and melted the charge was measured. Positive charge appeared on all the particles.

Results show that as the particles frozen in the airstream melted, electrification steadily increased. The same thing happened when the particles frozen in the still air melted, though the charges were less — about one-sixth of those from the other kind. These results suggest that the rate of freezing when an ice particle forms is the main factor controlling the charge it acquires when it melts in moving air.

Air bubbles in the ice certainly seem to play a part in the build-up of the melting charges. All the ice particles had an opaque core with a lot of tiny bubbles and some large ones. In general, with both types of particles the core became larger and the num-

(Continued on page 2)

Amchitka Test

(Continued from page 3)

on the Pacific coast, apparently were lost in cliff falls. One eagle nesting site on each coast appears unstable and subject to weather damage. Eagles often change nesting sites, and it is believed that the losses will not affect the population. No peregrine falcon nesting sites used in 1971 were lost, but one used in 1969 and 1970 was believed gone.

Hundreds of dead freshwater fish were found on the borders of small lakes near Cannikin ground zero. Most were sticklebacks, a small trash fish, and a great many of them were in patterns indicating their kill came from gale winds the day before Cannikin. Some Dolly Varden Char, a game fish, also were found dead. ●

Nuclear Plan in Perspective

(Continued from page 7)

No worthwhile progress can be achieved unless there is sharing of responsibilities and activities. Science and industry have become so complicated that it is impossible for an individual to sit in judgement or direct the entire gamut of activities.

IITs Vital Role

An R & D organisation can contribute only if it is manned by efficient scientific and technical men. In his endeavour, our universities and and institutes, specially the IITs, play a very vital role. We have always followed the policy of helping universities and IITs in every way possible. We have never deprived them of their professors and other teaching staff as we consider that such a course leads to short-term gains, but creates long range problems. We are in fact a part of the University of Bombay, and in so far as the IITs are concerned, we have reciprocal arrangements whereby their professors lecture in our Training School and our specialists impart training to their students. Our programme calls for the induction of several hundred scientists and engineers into the Atomic Energy Commission's various activities in the next ten years and we find that our own training facilities are not able to cater to our demands. To overcome this deficiency we are considering the setting up of a system of retraining our scientists and have sent some of our physicists to be retrained as metallurgical engineers and electronics engineers. We are sure that this type of a composite scientist would be most useful for our expanding programmes. Simultaneously, to reduce our research and development load, we are formulating methods by which we can pass on a part of this work to the IITs and the universities. It would call for pooling of resources whereby our own expertise could be expanded by using the talents available in these institutions which would result in developing the right type of manpower besides carrying out basic research which would lead to new indigenous technologies. Whilst applied research can fill the need of a country for industrial progress upto a point, sustained industrialisation requires basic research, as otherwise the sources of information and ideas dry up.

One can therefore see that for India, the creation of the right atmosphere for R & D organisations and the application of this R & D is important not only as an end in itself but for the development of the country in general. Whilst economics is the yardstick for judging the success or failure of any programme of investment, it should also be viewed in the larger context of long range benefits and the associated fall-out in self-reliance and self-sufficiency. The question is not whether the country can by-pass the stage of self-reliance by massive imports but whether we can afford to cut back in our efforts to become technologically and therefore economically independent. ●

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 1, and printed by him at Conway Printers Pvt. Ltd., 167c, Dr. A. B. Road, Worli, Bombay 18.

Registered No. R. N. 9002/62

NUCLEAR INDIA

VOL. 10. No. 7 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY MARCH 1972

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BARC Offers Knowhow for Advanced Gas Chromatograph

THE Bhabha Atomic Research Centre, Trombay, is offering knowhow and technical guidance for indigenous manufacture of an advanced type of automatic preparative gas chromatograph which it has developed. The instrument has been designed and fabricated by the Chemistry Division of the Centre which has already built-up considerable expertise in the field of gas chromatography.

Gas chromatography is a means of detecting and separating the different constitutents of a complex volatile mixture. Because of the very high efficiency of this method, even extremely complex mixtures containing scores of different constituents can be processed and the components separated in a remarkably short time. This unit would thus be of immense value to scientists engaged in research work in the area of flavours, biochemistry, food odours, perfumes, pharmaceuticals and drugs, or in any field where there is need to separate and collect constituents of a volatile mixture to a high degree of purity.

Versatile Unit

The BARC instrument reflects a high level of sophistication and is built to operate automatically. It consists of the following parts : (i) an automatic adjustable volume sample introduction assembly (ii) the basic gas chromatograph with its thermal conductivity detector, (iii) automatic fraction collection device and (iv) recycling programme-logic controller.

The equipment is designed to operate upto a temperature of 300°C and is capable of collecting any five components, as set by the programme, out of a maximum of 20-24 components of a complex mixture. By setting the programme-logic controller appropriately, the equipment would automatically introduce a measured quantity of the sample into the gas chromatograph, separate it into its constituents, detect them and collect the five desired fractions. This process gets repeated automatically day and night until the desired volumes of the purified materials have been obtained.

The main instrument is housed in a case measuring about 45 x 45 x 80 cms, with a rack to house the recorder, power supply, temperature controller and the recycle programme logic controller.

A complex instrument of this type if imported would cost well over Rs. 75,000 in foreign exchange alone. The BARC developed unit uses less than Rs. 500 worth of imported components, excluding the recorder.

Full particulars and terms may be obtained by writing to the Director, BARC. ●

Inside

COSMIC RAY STUDIES FROM LUNAR SAMPLES

Arvi Station Named after Dr. Sarabhai

THE Satellite Communications Earth Station at Arvi near Poona was named the Vikram Earth Station and dedicated to the nation by the President Shri V. V. Giri at a ceremony at New Delhi on February 26, on its completion of one year of operation.



The station is being operated by the Overseas Communications Service of the Ministry of Communications.

With this gesture, the OCS and the nation have paid a rich tribute to the late Dr. Vikram Sarabhai for his contribution to the space communications effort in the country. Under the late AEC Chairman's leadership and guidance, the Department of Atomic Energy played a major role in building the Station with considerable Indian expertise and material.

Both President Giri and Shri H.N. Bahuguna, the Minister for Communications paid handsome tributes to the engineers and technicians of the OCS, the Department of Atomic Energy, the Indian Telephone Industries and the large number of Indian engineering firms who participated in building the sophisticated station to a standard far exceeding that demanded by the International Consortium for Satellite Communications (INTELSAT). "It is an achievement about which our engineers can be rightly proud of," said Shri Giri. "The late Dr. Vikram Sarabhai was a man of rare vision. Space technology was dear to his

(Continued on page 7)

GRAVITY WAVES OR NOT?

Gravitational radiation, the so called "gravity-waves", have now made their appearance in the press. But whether they have really been detected has not yet been proved. The whole question of detecting them is the subject of international collaboration and a number of detectors are being built in laboratories in countries the world over, including Britain.

DETECTING such waves needs extraordinarily sensitive instruments. Basically, they must work by detecting the relative acceleration of two masses separated by some distance. Sensitivity will vary according to the direction of the arrival of the gravity wave. The relative force is turned into an electrical signal by piezoelectric material, a material that will produce a charge if its shape is changed, for example by pressure.

Experiments in the USA with one detector at Maryland University and another at the Argonne Laboratory a thousand kilometres away have been done, using an aluminium cylinder, suspended in a vacuum. The cylinder's lowest normal frequency of oscillation along its length is 1660 Hz. Piezo-electric material glued to the surface of the cylinder converts mechanical oscillations into electrical ones which can be amplified and recorded.

Origin and Causes

A gravity wave can produce tiny oscillations in the cylinder, which, of course, may be masked by random "noise", so the results from one detector are compared with those from another to see if there is a match of signals, evidence of a gravity wave. A signal, nevertheless, could still be caused by seismic, electromagnetic or cosmic ray disturbance and other arrangements have to be made to sort these out, too, so that what is left is a gravity wave signal.

Results so far appear to show that gravitational waves have arrived at a rate of about one a day and that they cluster as if the sources of the waves are at the centre of the Galaxy.

The origin and causes of gravitational radiation mean navigating the difficult stretches of Einsteinian physics. But, assuming that waves are radiated, they would certainly be extremely weak compared with electromagnetic waves. Most of the power of gravitational waves in the solar system, expected to be produced by planets moving round the Sun, is produced by Jupiter and amounts to about 450 watts and a similar amount comes from the Sun.

Yet the power of electromagnetic waves from the Sun is about 10^{24} times larger. More powerful gravitational waves could come from a collapsing stellar mass but even so a gravitational pulse received at the Earth from it would last only a minute time. A collapsing star ten times as massive as the Sun would produce a pulse lasting probably less than a thousandth of a second.

Professor P.B. Fellgett of Reading University, England, and Dr. D. W. Sciama of the Department of Astrophysics at Oxford, in a survey of gravitational wave astronomy, say that if the US observations are correct, they provide some difficulties to astronomers.

Loss of Energy, Mass

The rate of events is high, so it may be that processes occurring in the centre of the Galaxy are different from those that can be studied in detail in the parts nearer to us. Secondly, the Galaxy must be losing energy and mass by gravitational radiation at a rate of several hundred solar masses a year. Though these difficulties are not insurmountable, the claims must be tested by independent experiments with other detectors.

They say also that, as well as the piezo-electric method, others, including capacitive and optical methods, ought to be explored in detecting the relative acceleration of the two masses. The preferred form of detector at present is a cylindrical bar, split into two halves with the piezo-electric material sandwiched between the two halves.

The wave form of a gravitational signal from the most likely source of radiation — the gravitational collapse of a steller body or the capture of one collapsed object by another — can be predicted, as also can its duration.

Assuming that the waves travel on average over the distance from the Earth to the centre of the Galaxy, the energy needed to produce a detectable signal and the signal's frequency can be calculated.

This frequency is near to that at which detectors have been resonated. But it is hard to believe that an object of the necessary mass collapses or captures another almost every day, which is what results so far seem to imply. Perhaps, Fellgett and Sciama say, it would be better to make a detector more sensitive to the occasional slow event that could be produced by a super-massive object or to concentrate on fast events taking place close to Earth on a galactic scale.

They conclude that, theoretically, it would be surprising if gravitational radiation did not exist, though it is not proved. Probably, uncertainties will be resolved one way or another in the next twelve months. (*SPECTRUM* 1971/90)

COSMIC RAY STUDIES FROM LUNAR SAMPLES

The property of silicate grains to record the effects of cosmic rays and preserve them over long periods of time make the lunar grains ideal probes for studying the behaviour of cosmic rays in the past. The work carried out at the Tata Institute of Fundamental Research* has revealed the composition and energy spectrum of cosmic rays, particularly those generated in solar flares over past millions of years, for which little information has thus far been available.

N. BHANDARI and J. N. GOSWAMI
Tata Institute of Fundamental Research, Bombay

AS a chronological link between the present-day earth and the primitive solar nebula, the moon and meteorities occupy a special position in our solar system. These extraterrestrial objects have proved invaluable in the understanding of chemical evolution of planetary bodies. Besides this however, their great scientific value lies in the records of solar activity, solar wind, cosmic rays and other interplanetary phenomenon. Lying undisturbed on the surface of the moon for millions of years, each lunar grain is packed with a wide variety of information of diverse origin. In the past few years, the lunar samples have proved to be of great interest as space probes and have revealed a great deal of information about cosmic rays, their time variations, modulation and composition.

Unlike the terrestrial rocks which are exposed only to secondary cosmic rays because of the dense atmosphere, lunar surface soil and rocks show records of primary cosmic rays in abundance. In fact, the radiation damage due to cosmic rays and sputtering due to solar wind ions is quite intense and forms one of the important processes involved in modifying the surfaces of grains. Three types of effects can be easily seen. The implantation of solar wind ions, which can be most easily distinguished as rare gases evolving out on heating, the radioactivity produced by protons and alpha particles resulting in a host of radioisotopes not found in terrestrial rocks, and the solid state damage due to heavy cosmic ray nuclei ($Z > 20$) which can be revealed as tracks after suitable chemical development of certain minerals *(see figures on pages 4, & 5)*.

Occasional solar flares which produce cosmic rays dominate the other component, galactic in origin, at lower energy and therefore lunar samples offer a means to study the solar cosmic rays without much interference. In fact, the accumulated damage produced by the solar cosmic ray nuclei in lunar surface components is so large that usually it is not possible to resolve them optically and one has to resort to electron microscopy. **The electron microscope laboratory at the TIFR has therefore been particularly useful in the study of these fossil tracks at high magnification of 10,000 — 30,000X**

For the purpose of this study, through orthogonal slices from several lunar rocks were taken and the density of tracks as a function of depth were studied. In addition surface chips from several other lunar rocks as well as grains from the soil provided information on low energy (> 0.5 MeV/n) component. Long cores taken from the lunar surface soil proved specially valuable in studying cosmic ray records at different times in the past since some of the cores showed well preserved strata which were irradiated to cosmic rays in a time sequence which could be determined. It has been established for example, that the 60 cm long core taken at the Apollo-12 site consisted of some ten layers of discrete ejecta deposited one over the other over the past 300 million years. The longest core now available is about 2.5 metres from the Apollo-15 site and is expected to take us back farther in time.

Some rocks on the moon, particularly the majority of rocks at the Apollo-14 site are breccias, formed by compaction of soil grains. Although some of them are found to have undergone subsequent heating or recrystallisation, others contain fragments which still preserve records of the primitive irradiation. These specimens are particularly valuable in studying the characteristics of cosmic rays at the time individual fragments were exposed.

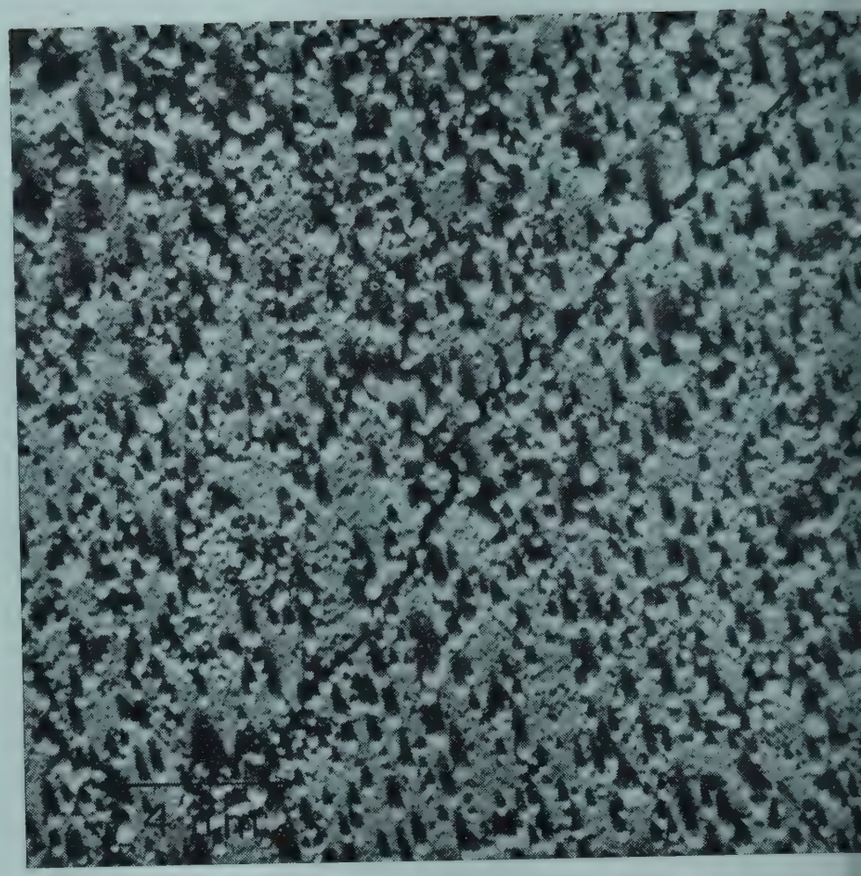
Since each lunar grain contains records of a wide variety, it was considered desirable to study a variety of minerals which have different characteristics and to develop selective techniques which would allow us to obtain information on different aspects of interest. Keeping this in view an etching technique for the olivine group of minerals was developed and, apart from the plastic replication technique, optical methods of measurements with high resolution were evolved.

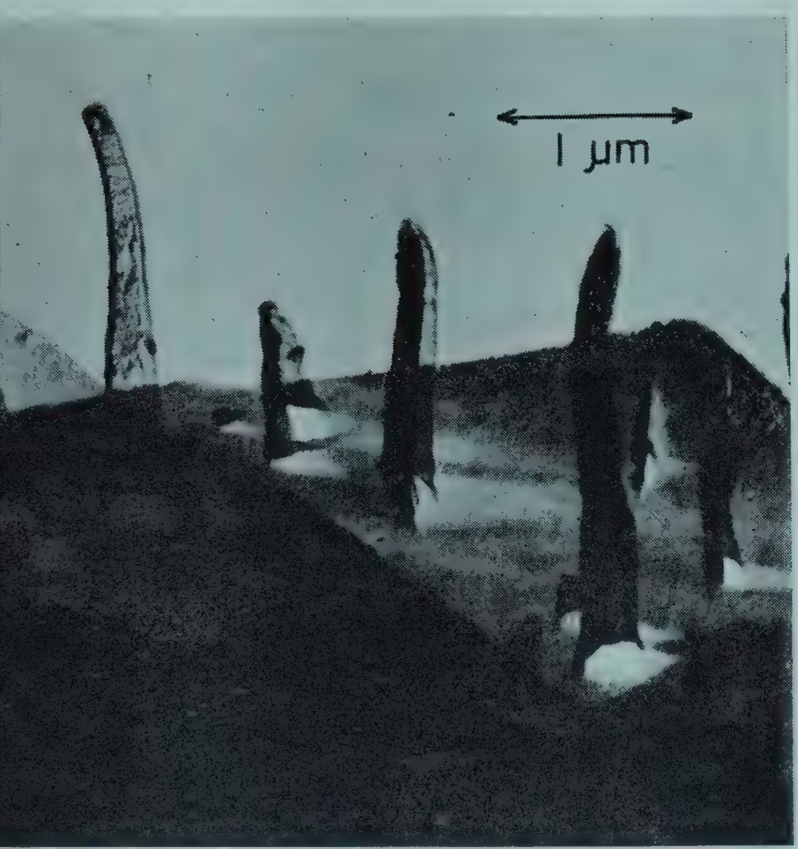
It has been estimated that on the moon, about a millimeter of the rock surface is eroded over a period of a

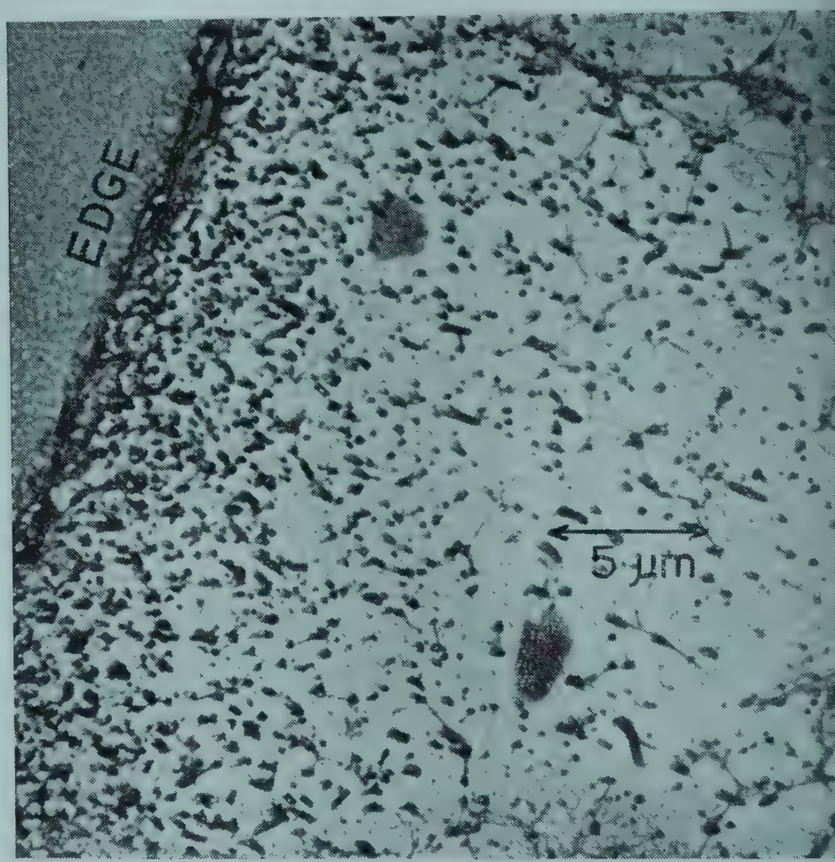
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* A group consisting of N. Bhandari, S. G. Bhat, J. N. Goswami, S. K. Gupta, A. S. Tamhane, V. S. Venkatavaradan and headed by Prof. D. Lal has been responsible for analysis of Lunar Samples at the Tata Institute. The experimental work is contained in the papers presented at the 3rd Lunar Science conference held at Houston, January 1972.





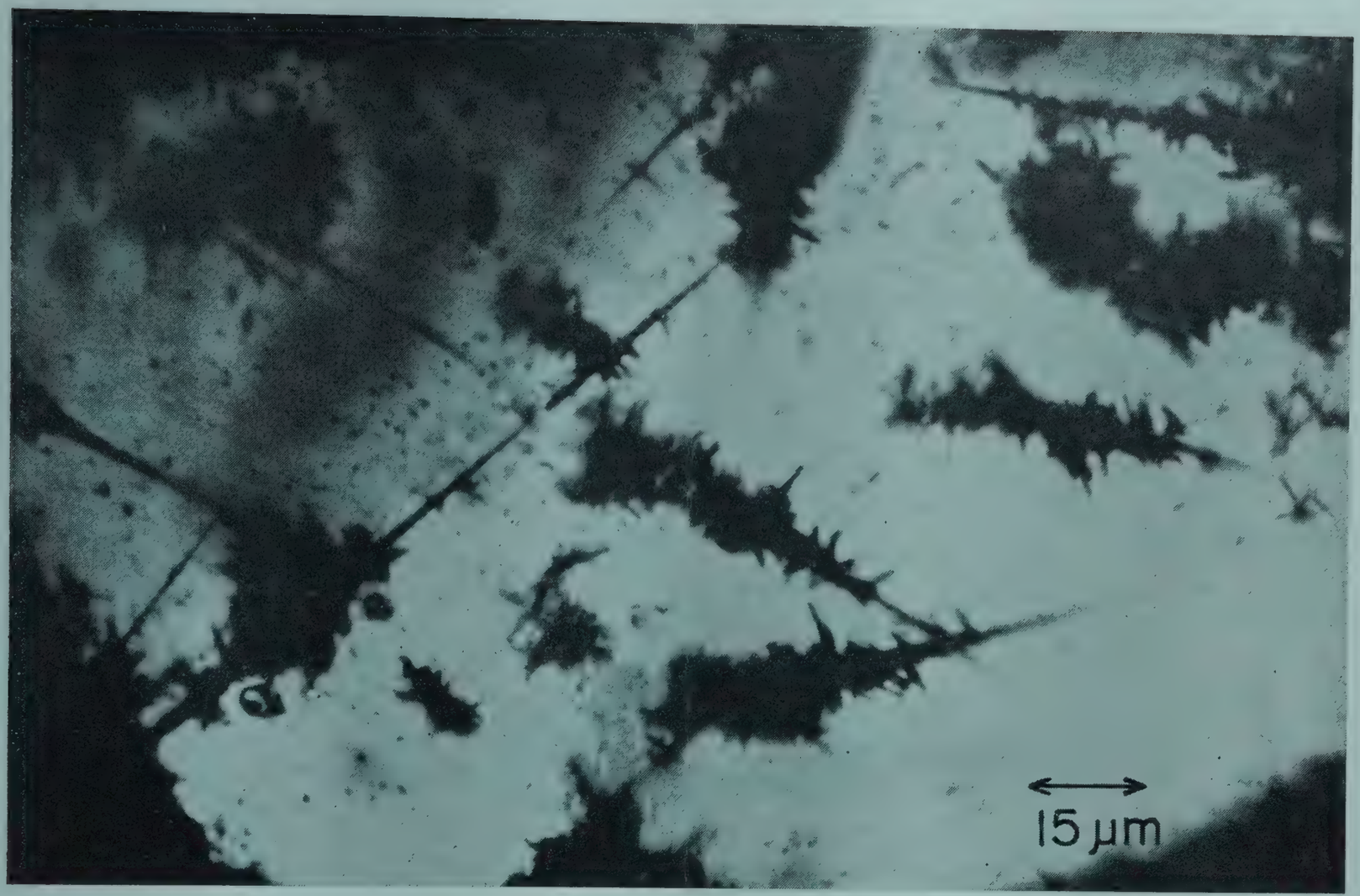




The electron micrograph of plastic replicas of etched feldspar and pyroxene crystals taken from lunar rocks and soil. Many of them (eg. bottom right) show steep decrease in density of tracks with depth, which is a manifestation of the primary energy spectrum of these nuclei (20 < Z > 28). The Philips-200 electron microscope at TIFR was used for this study. Most of the tracks are due to iron group nuclei.

(Continued from page 3)

million years due to the impact of micrometeorites. Thus, the tracks acquired by the surface regions of the rock are governed by erosion, which introduces an additional complication in determining the primary energy spectra. Also, on the lunar surface there are



The heavier nuclei, Z > 30 are rare in cosmic rays, being about 0.03% of the iron nuclei. They leave long tracks in silicate minerals as seen here in case of an olivine crystal from a lunar rock. The barbed wire appearance of these tracks result from intersecting short tracks due to iron nuclei.

processes of mixing, burial and excavation, akin to gardening, which make it difficult to determine the precise geometry of exposure, essential for correct interpretation of the observed effects. These complications call for appropriate selection of samples, and in these cases, at energies greater than 50 MeV/n, corresponding to about a millimeter depth, it is relatively straight-forward to relate the observed track data to primary cosmic radiation. From a detailed analysis made on a dozen rocks from Apollo-11, 12 and 14 sites so far, it has been possible to obtain an "average" energy spectrum of the iron group nuclei upto energies of 5 BeV/n, corresponding to the maximum size of the rocks available so far.

Optical examination of etched crystals is more rewarding than the study of replica under electron microscope and can be conveniently employed when track densities are below 5 x 10^7 cm^{-2} the advantage being that the track lengths can also be measured. The length of a track registered is only charge dependent, being independent of the initial energy, above a certain threshold characteristic of the mineral. Under controlled development, the track lengths can be related to track forming nuclei. In common silicate minerals the lengths vary from barely distinguishable pits to about a millimeter. The most dominant tracks having a length of about 12 microns can be identified with iron nucleus which is the most abundant of cosmic ray nuclei recorded. The longest tracks, due to heaviest elements in cosmic rays, *e.g.* uranium or transuranic elements are very rare, reflecting upon the composition of cosmic rays and stellar processes where they originate. Current studies are devoted to study of nuclei between calcium and uranium which have been observed to occur as discrete groups in certain charge regions, consistent with their cosmic abundance.

Thus by measurements of track lengths, it becomes possible to determine composition and evaluate the energy dependence of different nuclei in cosmic rays which provide some clues to the acceleration and escape mechanism in the source regions. The observations at low energy can directly be compared with abundances derived from the study of spectral lines from the sun and this gives us some insight into the regions on the sun where solar cosmic rays are generated. In case of galactic cosmic rays, their abundances in the lunar and meteoritic samples reflect upon the processes governing nucleosynthesis and their propagation through interstellar medium. The moon being situated at 1 A. U. and the meteorites coming from 2-3 A. U. offer an important clue to the importance of the interplanetary magnetic fields in modifying cosmic rays in the solar system.

(Continued on page 6)

Newsbriefs

Soviet Nuclear Changes

A qualitative change is to take place in Soviet atomic power engineering according to Vladimir Kirillin, Chairman of the USSR State Committee for Science and Technology. "I have in mind the development of the fast neutron reactors", Kirillin said. "Traditional reactors consume only an insignificant proportion of natural uranium. The new units make much fuller use of the natural reserves of uranium". In 1972 such a reactor with a design capacity of 350 MW(e) will be commissioned at the Shavchenko atomic power plant, and in some 10-15 years time, fast neutron reactors will evidently become the main trend in the development of the atomic power industry. Another highly promising trend of technological progress is the development of practical use of superconductive materials. Extremely fascinating prospects are opening before electric engineering in this field: power transmission lines with sharply reduced losses, light-weight transformers and electrical machines of unusually high efficiency, and compact electromagnets capable of generating very powerful fields.

(*Nuclear Engineering International*, December 1971)

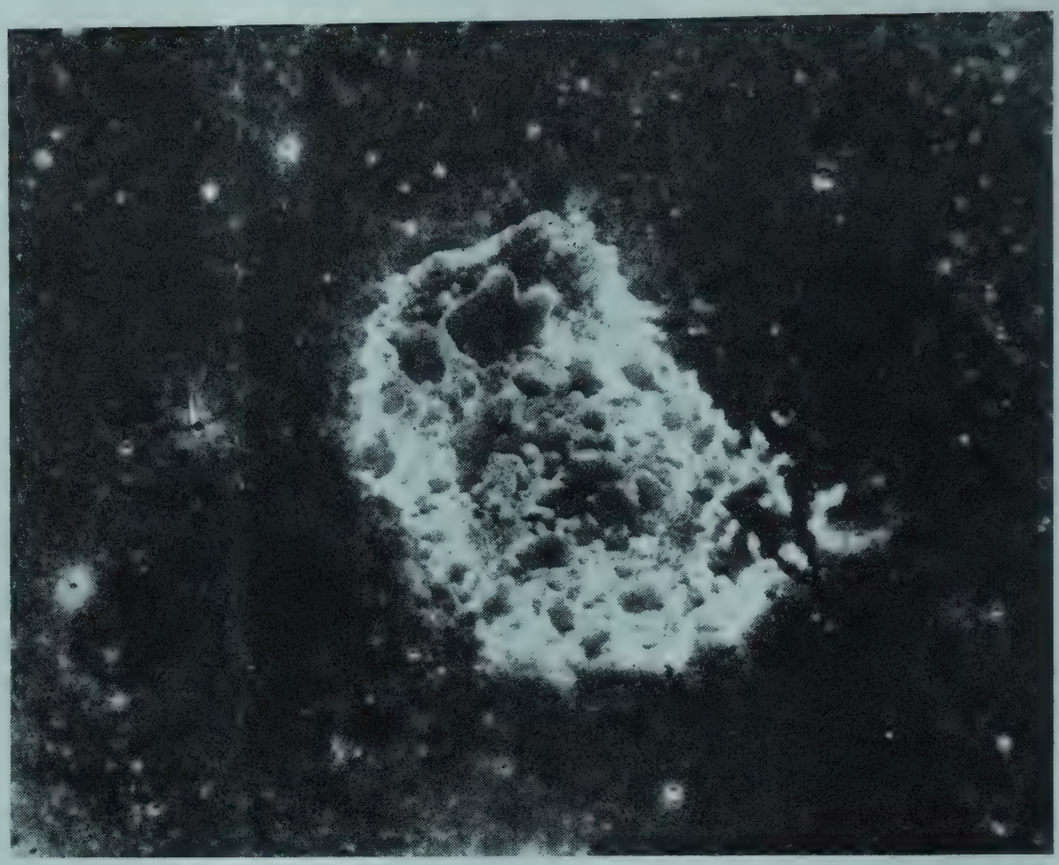
Pakistan's KANUPP Commissioning Delayed

The Indo-Pakistani conflict may have seriously delayed commissioning of the KANUPP nuclear station outside of Karachi. The station output has been held at the 40-megawatt level because the Pakistani electrical grid cannot absorb any more at this time.

The KANUPP station delivered its first power to the Karachi Electric Supply Co. 1:15 pm local time October 18, 1971. The low-power tests were at 30 MWe, and the station will be gradually brought up to design capacity of 125 MWe.

(*Nuclear Canada*, January 1972)

Unearthly Site



VOLCANO ON THE MOON — This three-kilometre-wide basin on the Moon, photographed from orbit by the Apollo-15 command ship last summer, is strewn with white material and dark domes that resemble blisters. U.S. scientists say the feature is unique on the lunar surface and believe it to be volcanic in origin. They add that the smooth surfaces of the domes indicate a relatively young age. Called a "caldera," the depression is located in the uplands between the Sea of Serenity and the Sea of Rains on the Moon's nearside. Its shape, resembling the letter "D", has puzzled the scientists since most calderas on earth are circular. (Courtesy USIS).

Lunar Rock Studies at TIFR

(Continued from page 5)

Contemporary cosmic ray studies made with the help of rockets, balloons and satellites only reveal the characteristics of cosmic rays on a small time differential representing minutes, days or years. From these studies a fairly good knowledge of cosmic rays over the past two solar cycles has been acquired. On the other hand the extraterrestrial material like lunar or meteoritic samples, irradiated naturally to interplanetary radiation, store the effects for long periods of time usually ranging for periods of millions of years and afford the only information on cosmic rays which goes back to such a remote past. Thus a comparison between contemporary and pre-historic cosmic rays becomes possible. Although a detailed evaluation of temporal variations must await further studies, the indications so far are that the time averaged fluxes of solar or galactic cosmic rays are not very different now than in the past. The fluctuations on small time scales as during solar cycles or periods of solar flares are of course well established, but the long term "average" variations are found to be within a factor of two, as revealed by the concentrations of induced radionuclides.

The fact that different lunar samples are exposed to cosmic rays at different periods of times and these records are subsequently left unaltered, opens up the possibility of studying the activity of the sun in the remote past as a function of time which will emerge as samples from different epochs and strata on the lunar surface, become available.

Vikram Earth Station Dedicated

(Continued from page 1)

heart and it is fitting that the Station bears his illustrious name."

Referring to Dr. Sarabhai's interest in the project, Shri Bahuguna, Minister for Communications, said the late Chairman's vision and faith had yielded permanent benefits in terms of knowhow and self-confidence acquired by Indian engineers in an advanced area of technology.

The Station stands on a site of about 92 hectares at an altitude of 680 metres. Arvi is in the middle of a natural bowl formed by surrounding low-lying hills, affording natural shielding against outside microwave systems.

The Vikram Earth Station works with the Indian Ocean Satellite IS III (F3), located at a nominal longitude of 61.4°E and is capable of providing direct links to all countries from U.K. in the far West, to Japan in the far East. The station enjoys a favourable look angle of 64° to the Indian Ocean Satellite.

The Station has been planned to provide all forms of international telecommunication facilities including telephone, telex, telegrams, radio photos and data transmissions. Additionally, the Station can handle television programmes whenever relayed *via* satellites. The station has been designed for 99.9 per cent reliability of operation, achieved by means of stand-by facilities. ●

CORRIGENDUM

On page 13 of the January issue of *Nuclear India* it has been stated that Dr. Sarabhai became a Member of the Atomic Energy Commission in 1961. Also that the Indian Institute of Management at Ahmedabad was started in 1955. It is regretted that these dates are incorrect. Dr. Sarabhai was appointed Member of the Atomic Energy Commission on January 1, 1966. The Indian Institute of Management was started in June 1962.

Propellant Fuel Complex at Thumba

THE foundation stone for a propellant fuel complex was laid at Thumba on February 22, by Prof. M. G. K. Menon, Chairman, Indian Space Research Organisation. The unit is expected to go into production by the middle of 1973. With the setting up of the complex, India could be said to be well on its way towards self-sufficiency in the basic fuel requirements of high-energy propellants for rockets and space vehicles.

The complex will produce a large variety of polymeric fuel binders like poly-sulfides, polyurethanes, polybutadienes, etc. and plasticisers, catalysts and stabilisers—items which are not readily available in the country.

Speaking on the occasion, Prof. Menon stressed the need for indigenous production of such highly critical and sensitive elements and also the importance of producing them within Thumba itself to ensure the quality of the products. Prof. Menon explained that the complex was a development of R and D work done in the area by the Propellant Engineering Division of ISRO.

He added that the complex—reflecting a new concept in medium-scale production of sophisticated chemical items—would employ completely indigenous designs for its various production units.

The plant will have a capacity of 200 tonnes per year of various polymers and allied chemicals and will give employment to about 100 person in different diciplines. The total outlay for it would be Rs. 60 lakhs. It is expected to achieve import substitution of the value of Rs. 1 crore per year. ●

STATEMENT OF OWNERSHIP

Statement of particulars regarding NUCLEAR INDIA, as required to be published under Section 19-D, sub-section (b) of the Press and Registration of Books Act read with Rule 8 for the Registration of Newspapers (Central Rules, 1956 as amended).

1. Place of Publication	Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay 1.
2. Periodicity of Publication	Monthly
3. Publisher's Name Nationality Address	Jagannath Sharma Indian Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay 1.
4. Printer's Name Nationality Address	Jagannath Sharma Indian Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay 1.
5. Editor's Name Nationality Address	Jagannath Sharma Indian Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay 1.
6. Name and Address of the Owner	Department of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 1.

I, Jagannath Sharma, hereby declare that the particulars given above are true to the best of my knowledge and belief.

March 1, 1972 (Sd.) JAGANNATH SHARMA

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Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 1, and printed by him at Conway Printers Pvt. Ltd., 167c, Dr. A. B. Road, Worli, Bombay-18.

Registered No. R. N. 9002/62

NUCLEAR INDIA

VOL. 10, NO. 9 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY MAY 1972

Nuclear Power

THE Tarapur Atomic Power Station, commissioned in October 1969, completed 2½ years of commercial operation by the end of the financial year. The Station generated 4,590 million units of electricity upto March 31, 1972. Till March 31, 1971, Tarapur operated with high efficiency but during the succeeding twelve months, its performance was affected due to some special problems.

In the Rajasthan Atomic Power Project, all construction work on Unit I has been completed and commissioning activities are in full swing. In Unit II, all major civil works, including prestressed concrete domes, have been completed and installation of nuclear and conventional components is in progress. Unit I of the Rajasthan Station is expected to become "critical" around June 1972, while Unit II will become "critical" in March 1975.

At the Madras Atomic Power Project, designs for civil structures for the sea water system, *i.e.* submarine tunnel, off-shore intake, pump house, conduits, seal-well and out-falls, etc. and the vapour suppression system, shield wall between reactor boilers and primary pump in the reactor building, and various auxiliary cooling systems inside the reactor building have been completed. Work has also been taken in hand for construction of the reactor and turbine buildings of Unit II of the Station.

Nuclear Fuel

THE Atomic Fuels Division of the Bhabha Atomic Research Centre, Trombay, is responsible for producing the fuel elements and components for the research reactors CIRUS and ZERLINA at Trombay. It is also engaged in development work connected with fabrication of fissile and fertile elements, and components for nuclear power reactors, including fast reactors envisaged in the 10-Year Profile. The Division has fabricated half of the initial fuel and standby fuel for Unit I of Rajasthan Atomic Power Project (RAPP-I). The process knowhow and production technology developed at the Division are being used to build the Nuclear Fuel Complex at Hyderabad which will meet the needs of nuclear power plants under construction as well as those being planned. The Nuclear Fuel Complex (NFC) at Hyderabad has been planned to make the country self-sufficient in nuclear fuel and zircaloy structural materials required for the nuclear power programmes. The Complex includes a zirconium oxide plant, a zirconium sponge plant, an enriched uranium oxide plant, an enriched fuel fabrication plant, ceramic fuel fabrication plant, a zircaloy fabrication plant, and a special materials plant. It has been decided to add a Stainless Steel Seamless Tube plant with an annual output of 2,000 tonnes as part of the NFC. Some of the units of NFC have already gone into trial production. The Zirconium Oxide Plant was commissioned

(Continued on page 2)

All projects in hand and the planning of major projects envisaged in the 10-year profile for atomic energy and space research (proposed in May 1970) are making steady progress according to the Annual Report of the Department of Atomic Energy released recently. Following are some excerpts from the Report on work in major areas during the year 1971–1972.

New Nuclear Power Stations

A Site Selection Committee was appointed in September 1970 to examine suitable sites for new atomic power stations in the northern, western and southern electricity regions. The Committee has completed the work in the northern electricity region and is continuing its work in the western and southern electricity regions. Besides examination of site factors, the Committee's work in the northern region involved detailed investigations in regard to subsoil and seismological conditions for assessing the feasibility of adopting the available CANDU type reactor design to suit the poor subsoil and adverse seismic conditions prevailing in a large part of the region, and also to develop principal design parameters for redesigning the station equipment and systems. Considerable detailed electrical network studies were also carried out to assess the economic distribution of power from the various alternative sites. Questions relating to silt exclusion from cooling water, where the silt content is objectionably high, were studied in depth. The report of the Committee on the northern region has been received and a decision regarding a new atomic power station in the region will be taken shortly.

special article on page 8

Searchlight on the Stockholm Conference on Human Environment

(Continued from page 1)

in May 1971. Production of zirconium sponge commenced in June 1971. The main Zirconium Sponge Plant was subsequently commissioned in September 1971. The Uranium Oxide Plant began trial runs in October 1971 starting with the uranium concentrates from the Uranium Corporation of India Ltd. at Jaduguda. Civil works in the special materials plant, the enriched uranium oxide plant, and the enriched fuel fabrication plant have reached an advanced stage. The plants are expected to be commissioned during the second and third quarters of 1972.

Atomic Minerals

THE Atomic Minerals Division of the Department with its headquarters at New Delhi is responsible for survey, prospecting and development of uranium, thorium, beryllium, columbium-tantalum and other atomic minerals. During the year, as part of its investigations for uranium, the Division continued underground development work at Narwapahar and the Bhatin mining prospects in the Singhbhum Thrust Belt of Bihar. Geological and radiometric investigations for uranium were carried out in various parts of the Himalayas as well as in the peninsular India region.

Detailed investigations were also made for estimating ilmenite, monazite and other heavy minerals reserves in the beach sands along the Neendakara-Kayamkulam coast (Quilon, Kerala) and the Chatrapur coast (Ganges, Orissa).

Investigations for beryllium and other atomic minerals in pegmatities of the mica belts of Bihar and Rajasthan and in parts of Orissa, Madhya Pradesh, Gujarat, Tamil Nadu and Mysore were continued. Investigations for locating non-pegmatitic sources of columbium-tantalum were intensified in favourable host rocks, such as syenites, carbonatites etc. in parts of West Bengal, Rajasthan, Jammu and Kashmir, Himachal Pradesh, Tamil Nadu and Andhra Pradesh. The Division continued to collaborate with sister organizations of the Government and also rendered assistance to private parties and universities in the search for uranium.

Radioisotopes

The Isotope Division of the Bhabha Atomic Research Centre continued production, and development of applications of radioisotopes. During the year, the sale value of radioisotopes, equipment and services rendered by the Division totalled Rs. 37.73 lakhs, including Rs. 5.06 lakhs in export. Significant progress has been made at the Division in the designing, fabrication and setting up of large gamma irradiators. A variable dose gamma irradiation facility known as panoramic batch irradiator (PANBIT) has been constructed at Trombay. Loaded with an initial charge of 10,000 curies of cobalt-60, this facility is being used for the evaluation of processing parameters and development of wood polymer and fibre polymer composites. A panoramic field irradiator known as "gamma shine" has been developed specially for use in agricultural research. One such unit loaded with 1,000 curies of cobalt-60 has been installed at the Osmania University, Hyderabad for use in agricultural research.

Preliminary work on the setting up of a demonstration plant for irradiation sterilisation of medical products with United Nations Development Programme assistance has started at Trombay. The plant is expected to go into operation by the end of 1973. It will be capable of treating 300,000 cu.ft. (approx. 8,500 cu.m.) of medical products per year initially and is designed for a maximum capacity of 1 million cu. ft. (approx. 29,000 cu. m.) of materials. The products proposed to be sterilised in this facility include cottonwool, catheters, disposable syringes, sutures, surgeon's golves, etc.

Support Industries

TO support the atomic energy and space programme, the Department is engaged in industrial operations in certain vital areas. Three public sector undertakings : the Electronics Corporation of India Ltd. (ECIL), the Indian Rare Earths Ltd. (IRE) and the Uranium Corporation of India Ltd. (UCIL), are functioning under the Department. The Electronics Corporation of India Ltd. was established in April 1967. The year 1971-72 is thus the fifth year of its existence. During 1970-71, the Company made a net profit of Rs. 13.64 lakhs after providing for depreciation of Rs. 25.59 lakhs, interest of Rs. 10.83 lakhs and expenditure on R & D and social overheads amounting to Rs. 6.90 lakhs and Rs. 6.94 lakhs respectively.

For the year 1971-72, ECIL is likely to make a profit of Rs. 24.67 lakhs after providing for deferred expenditure of Rs. 6.57 lakhs and for other factors such as depreciation, interest etc. The Company has formulated a 5-year expansion programme (1971-76) which envisages an annual sales level of about Rs. 21 crores and an employment potential of 5,200 employees by the end of 1975-76. The cumulative investment in the Company by 1975-76 would be of the order of Rs. 1,150

Fuel Reprocessing

The output from the plutonium plant at Trombay increased considerably during 1971-72 as a result of some modifications carried out in this period. The processing of irradiated thorium for the recovery of uranium-233 was continued, and uranium-233 of high purity and good specifications was extracted. A considerable amount of work is being done for setting up a reprocessing development laboratory at the Reactor Research Centre, Kalpakkam. At Tarapur, construction of the main plant building for the power reactor fuel reprocessing plant has been completed.

Heavy Water

Three Heavy Water Plants — at Kota, Baroda and Tuticorin, — have been sanctioned and construction work is proceeding. There is already a small plant producing Heavy Water at the Nangal unit of the Fertilizer Corporation of India. It will be necessary to set up one or two more Heavy Water plants after the Tuticorin project, and a provision for this has been included in the IVth Plan.

lakhs. While the expansion programme envisages increase in production capacity of existing lines, and diversifications, its chief feature would be the role that the Company will play in the development and manufacture of small and medium-size computers.

The second undertaking is the Indian Rare Earths Ltd. with its headquarters at Bombay. The Company is operating plants at Trombay, and at Chavara, Alwaye and Manavalakurichi in the South for extracting thorium, and rare earths minerals from the beach sands of Kerala and Tamil Nadu. During 1971-72, IRE achieved a substantial increase in its turnover which works out to over Rs. 3 crores. The net profit for the year is likely to be of the order of Rs. 30 lakhs.

The Uranium Corporation of India Ltd. is operating the Uranium Mine and Mill at Jaduguda in Bihar. During 1971-72 uranium concentrates worth approximately Rs. 375 lakhs were produced against production valued at Rs. 373.5 lakhs in 1970-71. The net operating profit for 1970-71 after providing in full for depreciation and interest was Rs. 39.66 lakhs. The net operating results for 1971-72 are expected to reveal profits of the same order.

Biology, Food Technology

THE Biology and Agricultural Division of the Bhabha Atomic Research Centre continued its programme of mutation breeding in cereals, oilseeds and medicinal plants. Eight mutants with long, slender grains without the parental defect of white belly have been isolated from IR-8. Thirty-nine cultures with fine grains, clear belly and desirable plant type were selected from a cross between IR-8 and an induced mutant TR-5.

In addition to the groundnut variety TG-1, another, TG-3, has been recommended for pre-release seed multiplication this year after evaluation of its performance in 25 trials conducted under the All-India Coordinated Oilseeds Project of the Indian Council of Agricultural Research. Seven other groundnut mutants with high oil content gave increased yields over the parental variety consistently for a period of three years at Trombay.

The Biochemistry and Food Technology Division of BARC continued its research programme on basic and allied aspects of life sciences, and development of radiation preservation of foods. As in previous years, studies have been underway to develop radiation procedures for preservation of perishable foods. Large scale feasibility trials on extension of storage life of onions, disinfestation of wheat, and preservation of fish and fish products are being continued. At varous phases of these studies, liasion has been maintained with other concerned ministries of the Government of India. Microbial, sensory, and toxicity aspects of irradiated foods are being evaluated. Long and short term nutritional experiments for assessing wholesomeness are being done in case of promising food irradiation procedures. Studies are also on in the area of radiation disinfestation of foodgrains. In collaboration with the Food Corporation of India, large scale studies using about 15 tonnes of wheat have been completed.

Nuclear Medicine

CLINICAL nuclear medicine, training of medical personnel in the use of radioisotopes, and application of radioisotopes in medical research form the major responsibilities of the

Agro-Industrial Complex

Follow-up work on the report on the nuclear powered agro-industrial complex published in June 1970 was initiated for examining the feasibility of such a concept. As the economics of agriculture using desalted water as proposed in Kutch-Saurashtra complex is very much dependent on the conservation of desalted water, it is necessary to collect data on various aspects of agriculture using desalted water. To study these aspects, a pilot farm has been proposed in Gujarat where underground water will be demineralized before use, to simulate the use of desalted water.

Research work on desalination is being done at the Bhabha Atomic Research Centre by the Desalination and Effluent Engineering Division. Processes such as electrolysis, reverse osmosis, solvent extraction, long-tube vertical evaporation (LTVE), and multistage flash (MSF) have been tried. As the LTVE and MSF processes proved to be highly promising, detailed work was done on these. The Division has fabricated and assembled 5 multi-effect evaporators for the LTVE process for a 20,000 gallon per day (approx. 90,000 litres per day) desalination plant using double fluted tubes. The double fluted tubes were developed by this Division in 1970. The use of these tubes is likely to result in significant savings in the cost of desalination. In addition to the five multi-effect evaporators, equipment for a desalination unit of 30,000 gallons per day (approx. 1,36,000 litres per day) capacity, with longer double fluted tubes, is being fabricated.

To develop desalting techniques on a commercial scale, there is a proposal to install a 1 million gallons per day (approx. 45,460,000 litres per day) desalination plant. The facility will be utilized both as a production unit for potable water and as an experimental facility to gather useful data in the field.

Radiation Medicine Centre (RMC) of the Bhabha Atomic Research Centre. During the year, the RMC investigated about 5,000 patients with radioisotopes, some of whom were also given radiotherapy.

At the Tata Memorial Hospital which forms a part of the Tata Memorial Centre (TMC), Bombay, clinical research studies on treatment methods (surgery, radiation and chemotherapy) to improve the survival rate of cancer patients have been actively pursued. A programme to use cryosurgery techniques in the treatment of cancer is under way.

The screening programme for detecting anticancer properties of indigenous plants has given some useful results. Out of 500 species of plants screened so far, 6 plant extracts have shown good anticancer activity in experiments. Isolation and characterisation of active principles is in progress.

VEC Project

Construction work on the Variable Energy Cyclotron (VEC) at Calcutta is making progress. The Heavy Engineering Corporation (HEC), Ranchi, the Heavy Electricals (India) Ltd. of Bhopal, the Electronics Corporation of India Ltd., Hyderabad, the Garden Reach Workshops, Calcutta, the Indian Telephone Industries Ltd., Bangalore and a few private firms are collaborating with BARC in the fabrication of the equipment for the Cyclotron. The Cyclotron will be a modern research facility for high quality work in nuclear physics. Because of its high beam intensity, it can produce a variety of isotopes, which is not possible in nuclear reactors. The proposed facility will provide new opportunities for research workers from the universities and other institutions in the country which by themselves may not be able to set up and operate a large and complex machine of this type.

Reactor Research Centre

A Reactor Research Centre is being set up at Kalpakkam in Tamil Nadu for R & D in all aspects of fast reactor systems, particularly with reference to economic breeding of fissile material. The RRC facilities will include (i) laboratories for studies in reactor engineering, fuel reprocessing, safety research, fuel development and instrumentation development, (ii) a fuel reprocessing plant, (iii) a fuel fabrication facility, (iv) a pulsed fast reactor for materials research, in addition to physics research.

The first phase of the programme will be the design, construction and commissioning of the fast breeder test reactor, the pulsed fast reactor and associated facilities for research and development related to the fast reactor programme. The fast breeder test reactor of 15 MWe capacity will be basically similar to the Rhapsodie reactor at Cadarache in France. The French Atomic Energy Commission is assisting in the design and construction of this reactor.

Radioactivity Monitoring/Radiation Protection

THE Bhabha Atomic Research Centre continued its programme of Radiation Monitoring. It maintains a network of fall-out monitoring stations for assessing hazards to the population from radioactive contamination of the atmosphere. The Health Physics Division of the Centre has developed programmes related to (i) Environmental contamination from radioactive pollutants and (ii) atmospheric physics and chemistry. The meteorological data collected at Kalpakkam by the Division over the past two years have been used for the estimation of stack heights and permissible gaseous discharge rates from the atomic power station being built there. Similar studies were also made for conventional pollutants from the Waste Treatment Plant at Tarapur.

The Directorate of Radiation Protection of the Department is responsible for implementing a countrywide Radiation Hazards Control Programme. The DRP is responsible for assessing radiation doses received by personnel using radiation sources in various fields such as agriculture, industry, medicine and research. During the year its film badge service covered a total of 24,000 workers from 1,600 institutions. The corresponding figures for the preceding two years are 21,000 and 1,450 respectively. With the recent promulgation of the 'Radiation Protection Regulations 1971', this service will soon cover all radiation workers in the country. ●

Pollution Sickness

MOST people know that the number of respiratory illnesses reported will rise during periods of severe air pollution, such as during temperature inversions over major cities. Now comes word from the United States Environmental Protection Agency that even when pollution is moderate, people are more likely to feel sick and actually get sick than they would on clear days. Chest pains, shortness of breath and even doctor visits increase along with the levels of pollution.

After surveying 100 families in New York City last summer, the scientists at the EPA noted that city dwellers complained of symptoms of respiratory illness whenever the sulfur dioxide and particulate levels in the air rose. People who lived further away from the city were not affected by the pollution. *(USIS)* ●

ISRO Plans for Indigenous Satellite

Space Research

ON January 22, 1972, Prof. M. G. K. Menon, Director of TIFR and Secretary, Department of Electronics, assumed office as Chairman of the Indian Space Research Organization (ISRO) in addition to his other responsibilities. The Indian Space Research Organization (ISRO) manages the overall space research programme in the country. Space Research activities can be broadly classified under three heads : (i) Space Sciences, (ii) Space Technology and (iii) Space Applications.

Research programmes in aeronomy, X-ray and gamma ray astronomy, plasma physics, cosmic rays, studies of lunar material, and meteorites etc., under the first head, are conducted at the Physical Research Laboratory (PRL) at Ahmedabad, the Tata Institute of Fundamental Research (TIFR) at Bombay, and the Space Science and Technology Centre (SSTC) at Trivandrum. Space Technology, which includes all aspects of work related to the development of rockets, satellites, propellants, scientific payloads and ground and space instrumentation etc. is the primary responsibility of the Space Science and Technology Centre at Trivandrum, which also gets support in this area from the Physical Research Laboratory, TIFR, and the Thumba Equatorial Rocket Launching Station (TERLS)

Space Sciences

DURING the year, scientists at the Physical Research Laboratory carried out atmospheric soundings with payloads in rockets launched from Thumba. A good part of this work was done in collaboration with scientists from France, the USA, USSR, West Germany, the United Kingdom and Japan. Collaborative work was also done in the area of cosmic ray studies with TIFR, at the Balloon Facility at Hyderabad and at the Kolar Gold Fields. PRL is also engaged in the field of Radio Astronomy at Ootacamund where the Tata Institute of Fundamental Research operates one of the largest radio telescopes in the world.

At Gulmarg in Kashmir, the Department of Atomic Energy has a High Altitude Research Laboratory which provides facilities to institutions interested in conducting investigations at a high altitude and latitude within Indian territory. During the year, the Bhabha Atomic Research Centre, the Physical Research Laboratory, the Banaras Hindu University and the India Meteorological Department conducted studies at this laboratory.

Scientists at the Space Physics Division of the Space Science and Technology Centre, Thumba, continued their studies of the equatorial ionosphere with the help of ground-based experiments set up by them. At the Tata Institute of Fundamental Research, cosmic ray studies were continued on problems relating to cosmic rays and gamma rays using instruments flown on balloons. New observations were made of short time intensity variations and lack of pulsation at high frequency in the case of the newly identified 'Oscillator' Cyg X-1.

Studies of the energy spectrum of cosmic ray electrons were continued and results obtained in the energy region beyond 100 GeV. Attempts are being made to perfect the technique of particle detection using plastics for studying uranic and transuranic nuclei in cosmic rays.

TIFR scientists also studied in great detail several meteorites and lunar samples from Apollo 11, 12, 14, and 15 missions, obtained from various locations on the moon. New information

(Continued on page 6)

SPACE SCIENCE AND TECHNOLOGY CENTRE

The Space Science and Technology Centre at Thumba is engaged in indigenous development of sounding rockets, and satellite launching vehicles (SLV), control and guidance systems, on-board and ground electronics etc. to support rocket and satellite missions. During 1971-72, it finalized plans for facilities required for the proposed Satellite Launch Vehicle-3 (SLV3). Development activities in connection with SLV3 in the areas of propellants, nozzles and motor chambers, control systems, telemetering and tracking, are in different stages. Besides other basic facilities which are already operating, a propellant fuel complex is being built at Thumba. The unit is expected to go into production by the middle of 1973. With the commissioning of this complex, India will be considerably free from dependence on outside sources for basic fuel requirements of high energy propellants for rockets and space vehicles. The complex will produce high energy fuels like polysulphides, polyurethenes, polybutadienes etc. and plasticisers, catalysts and stabilisers — items which are not readily available in the country.

At Shriharikota, which is being developed as a satellite launching station, preliminary civil works including a 3.6 metre wide road from Sullurpet to Sriharikota Island have been completed. Buildings such as the block house, sub-station, rocket assembly and hardware stores etc. are under construction. Power and water supply facilities have been established. Radio communications between SHAR, the airport at Madras, and Thumba have been established. The first phase of the SHAR development programme was commissioned on October 9, 1971 when a Rohini RH-125 rocket was successfully launched. Two more Rohini RH-125 rockets were launched a day later with instrumented payloads for inflight testing of the roll control system being developed at SSTC. It is proposed to flight-test RH-300 and RH-516 motors from SHAR during 1972.

In the second phase, which is now in hand at SHAR, ground support facilities will be built for satellite launching.

Satellite Study of Earth Resources

(Continued from page 5)

on the intensity and composition of ancient cosmic rays and evolution of the lunar surface has been obtained. Fossil track studies in meteorities have led to the conclusion that super-heavy transuranic nucleides existed in the early history of the solar system.

The Ooty Radio Telescope, in operation since February 1970, is being used for studies in radio astronomy at a frequency of 326.5 MHz. Lunar occultations of more than 400 radio sources have been observed. The majority of the sources is very faint and hence far distant. Analysis of the occultation data is in progress.

The Thumba Equatorial Rocket Launching Station launched a total of 129 rockets upto March 31, 1972, of which 66 carried scientific experiments while 63 were test rockets. The rockets sent up included Soviet-built M-100 meteorological rockets, Nike-Apache rockets, Rohini 100, Rohini 125 and Menaka-I rockets, Dual Hawks, British-made Skuas and Petrels etc. The scientific rocket experiments for the study of the equatorial ionosphere, the electrojet, and the neutral upper atmosphere were conducted with payloads developed and fabricated at PRL.

A programme for expansion of the Experimental Satellite Communications Station at Ahmedabad was taken in hand on April 1, 1971. The Station's facilities are being enhanced to enable it to participate in the Satellite Instructional Television Experiment (SITE) planned for mid-1974. The augmented ESCES is expected to be operational by the end of 1973. As in previous years, it conducted two training courses in satellite communications technology during 1971-72. Besides the foreign fellows and Indian candidates sponsored by the various departments of the Government, final year undergraduate and postgraduate engineering students of electronics and allied disciplines from universities and technical institutions in the country underwent vacation training at ESCES.

An agreement was signed in September 1969 with NASA of USA for the use of its ATS-F satellite for a period of one year to conduct a joint satellite instructional TV experiment. A special SITE group has been set up in ISRO to undertake overall responsibility for the experiment. The experiment is expected to commence around mid-1974 and will evolve the broadcasting of Indian instructional TV programmes to about 5,000 villages in different parts of the country. About half of these sets will be of the direct reception type which can receive signals directly from the satellite and can thus be placed anywhere in the country. The other sets will be located in villages around cities where AIR-TV transmitters are already located or are planned to be set up. These will be linked upto the satellite system by appropriate earth station facility.

Besides SITE, ISRO proposes to collaborate with NASA on the use of the latter's planned experimental earth resources technology satellite for multidisciplinary investigations; the proposal envisages the study of pictures taken by the satellites for application in fields of oceanography, hydrology, geology, cartography, forestry and agriculture. Pictures from the first satellite ERTS-A are expected to become available in July 1972. ISRO proposes to act as a catalyst to enable Indian scientists to study the imagery thus obtained. ISRO also plans to purchase a few Hasselblad 70 mm cameras and multiband cameras which will be used to carry out surveys of ocean surface temperatures, underwater topography of the coastal belts, soil surveys, surveys of tree resources, tree diseases, floods etc. ●

NUCLEAR INDIA

is a monthly publication of the Department of Atomic Energy, published around the 20th of each month. To ensure prompt attention, all communications should be addressed to the Editor, NUCLEAR INDIA, Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay 1. While intimating change of address, the code and number given on the wrapper should be mentioned.

"We Mu

AS one who has been deeply interested in his subject since long before I had ever heard of the word ecology, I am naturally glad that people have woken up to the dangers which threaten the world as we know it. Since man first discovered that he could use nature for his own purposes he has been interfering with his environment. Man is a part of nature and only one of the many species who inhabit the earth. But he has treated it as his colony to exploit it. The scale of his intervention has now grown to a point where it has produced vast and disruptive changes which have already modified our existence more profoundly than any earlier human activity. Hence, the ecological problems with which we are now concerned embrace diverse aspects ranging from the economic, social, psychological problems of human settlements to the management and use of natural resources and the conservation of natural habitants. The earlier attitude of scorn has changed but some people still regard conservation and concern for ecology as something of a fad. Why worry if a few tigers and rhinos and a few plant species are wiped out? Your agenda paper gives the answer. "An environment in which animals and plants become extinct is not safe for the human being either." Besides, this attitude of mind is the same which regards one species of human being as superior to another.

Pollution is affected by four factors: the prevailing natural conditions; human population; the levels of production and consumption, and the level and use of technology. The environmental problems of the industrialised countries are the result of earlier exploitation as well as of present affluence, while those of the developing countries are primarily determined by the manner in which machines are used or abused. In the poorer societies these problems are essentially those of inadequate deve-

"Progres

Concentrate on the Arts of Preservation"

An extract from the Prime Minister Smt. Indira Gandhi's address at the First Meeting of the National Committee on Environmental Planning and Coordination, in New Delhi on April 12, 1972.

lopment and of continuing poverty, unsafe drinking water, malnutrition, poor sanitation, inadequate housing and disease.

As an international group of economists has pointed out, development is not the cause of most of these problems but the cure. The poorer countries cannot but look upon planned development as an instrument to improve the quality of life. Such planning, however, should entail a reappraisal of the objectives of development to provide more explicitly for the social and human needs of health, shelter, clean air, water and the beauty of natural surroundings. We should move away from the single dimension model which equates the growth of G. N. P. with development. Our emphasis should be on the qualitative improvement of life as a whole rather than on the quantitative growth of various sectors of economy. Our attention cannot be diverted from the main question before us which is to bring basic amenities within the reach of our people and to give them better living conditions without alienating them from nature and their environment, without despoiling nature of its beauty and of the freshness and purity so essential to our lives.

As our development progresses, perhaps we also shall have environmental problems akin to those in the developed countries. But we can learn from their experience. Through foresight and imaginative physical planning many potential dangers can be avoided or at least minimised. Concern with economic and social development need not be a choice between poverty and pollution. To most people progress has become synonymous with limitation of western models. But wherever we have followed these models from the industrial society and been insensitive to our own circumstances, the results have not been happy. The time has come for us to think deeply about the kind of progress we want. Should we not recast our priorities and ask ourselves what facilities are worth the price for us or for future generations? For instance, in the rural areas, a corrugated iron roof has become a sign of better living. It is certainly more durable than a thatched hut. At the same time, it is ugly to look at. It kills all artistic initiative and is not even suitable for our climate.

To give another example. For centuries Indian students have received instructions under trees. I myself had the privilege of going to a famous university where there were no class rooms. Yet today the school building seems to have acquired greater importance than what is taught or the quality of the teacher.

Shun Imitation

Just a few days ago, I came across a poem by a sensitive teenager which points to another aspect of our imitative thinking. She speaks of village boys playing with buffaloes in a muddy village pool and asks whether it would be an improvement to deprive them of this spontaneous joy by having them conform to the restrictions on the so-called better classes who are kept isolated from the sun and the wind in their covered, and sometimes heated, swimming pools! I was astounded to hear an otherwise sympathetic foreign visitor refer to people doing hard manual labour as human degradation. The personality of a man is not diminished by honest labour. Technology should certainly lighten his burden, but is it progress for vast numbers to be employed in monotonous mechanical tasks day in and day out blurring individuality and blunting their capacity to think and to feel? There are thousands of such instances. This sort of progress is avoidable but other aspects are far more complex. Individual programmes cannot be viewed in isolation but in terms of their impact on development and on environment. Some decisions will be difficult to take. For instance, fertilisers help enormously in increasing agricultural production. Yet they use up the soil. In countries still infested with mosquitoes, pesticides have been a boon. But we in Delhi can testify that the new strains which have developed are quite immune and resistant to the pesticides being used. Some of these pesticides which we and other countries have been using have killed off birds and other creatures and have harmed human beings. In some places, people are reverting to natural pest control, for example, breeding birds to devour insects.

Environment in Pervasive

A basic need for advance of any kind is energy. About half the energy consumed in our country is for domestic use and half this amount is supplied by firewoods. This is denuding our forests, eroding the soil, silting rivers and affecting the climate. Hence the importance of providing a cheap fuel substitute for those who use firewood. An integrated strategy is indicated. If we imitate what the industrialised countries did in their earlier phases, we might only add to the pollution without significantly raising per capita consumption levels.

By its very definition, environment is pervasive. Can there be environ-

(Continued on page 11)

leans Enriching of the Spirit and Clarity of Mind."

POLITICAL BACKGROUND

The proposal for holding an International Conference on Human Environment was put forth by Sweden in a resolution which the U. N. General Assembly adopted in 1968. The Conference is to provide guidelines for enhancing the human environment and to draft measures to stem its further impairment. The proposal attaches particular importance to programmes of Developing countries where it seeks to forestall degradation of the environment. A preparatory committee (PREPCOM), of 27 nations was constituted and Mr. Maurice Strong of the U. N. appointed as the Secretary-General of the Conference.

Mr. Maurice Strong is reported to have said recently in New Delhi that international bodies should approach and solve environmental problems politically. Political agreement becomes inescapable for achieving the objectives, although the purpose of bringing nations together is to find technological solutions for environmental problems and to promote a socio-economic balance between the different groups of people in a country.

Vienna Formula

In December last, the U.N. passed a resolution, known as the 'Vienna formula', sponsored by the USA, UK, France, Italy and Australia, which recommended that participation in the Conference should be restricted only to members of the UN and its agencies. The Vienna formula is seen as directed particularly against East Germany, which will thus be unable to take part whereas West Germany, which is a member of the W.H.O., becomes a fully accredited participant. **This technical disqualification and discrimination goes against the spirit of solidarity among nations, because the two States share a common geography, and an indivisible environment.** Russia and Czechoslovakia have boycotted the meetings of the PREPCOM and have threatened to stay away from the Conference.

War and the Environment

The Conference meets at a time of great political uncertainty. The war in Viet Nam brought the world very recently on the brink of disaster. **War is a ruthless destroyer of human environment.** For over a decade, this small developing country has been subjected to relentless bombing with chemical and explosive weapons which has resulted in the demolition of settlements, and industries, denudation of the land of vegetation, creation of large craters and, in the aggregate, destruction of the ecology of the land and death and disaster to man and other living creatures. The seas are polluted with sunken ships, discharging oil, and debris; navigational channels are blocked, and marine life in the region killed or driven away by undersea explosions. **It should be the primary duty of the environmentalists meeting at Stockholm to condemn acts of war as wanton destruction of man and his environment.** The Stockholm Conference will meet in vain if the environments carefully nurtured are to be destroyed through conflict among nations.

> International pollutants such as radioactive fallout and pesticides are of Western origin and injection and therefore the responsibility for monitoring and assessment should be with these nations.

PREPARATORY COMMITTEE

The 27-nation Preparatory Committee has circulated massive literature on the progress of committee work from time to time. Many of the reports of the Committee are already published. These reports give extensive guidelines for pollution control, planning of settlements, conservation, monitoring etc. The work was carried out by Inter-Governmental Working Groups (IGWG) on the following special topics:

i) Drafting of a Declaration of Human Environment
ii) Marine pollution and ocean dumping
iii) Monitoring of pollutants
iv) Natural, cultural and historical significance of environment (World Heritage Foundation) and
v) Soil degradation.

The reports describe the issues extensively, giving general guidance which is familiar to professionals in the field. There is no specific guidance on special subjects nor indications of assistance/aid available for countries looking for such aid. There is an undercurrent of concern expressed on the degradation of human environment as a result of the Developing countries continuing with their developing programmes. The need for a special fund to aid Developing countries to meet the cost of antipollution measures is discussed at one stage and is given up as premature.

Intergovernmental Working Groups

Declaration of Human Environment: A principal objective of the Conference is to pledge the nations to the protection and conservation of the environment.

The Declaration of Human Environment was originally intended to be a concise and inspirational document, embodying the social rights of the individual and the need for solidarity in dealing with environmental problems.

The IGWG, which was set up to draft the declaration, found it appro-

SEARCHLIGHT ON THE STOCKHOLM CO

priate instead to list out principles and policies which the people and the states should consider to enhance the environment. Much of the inspirational character and brevity dropped off in the process. The draft declaration inter alia asks the Big Powers to spare the environment from weapons-tests, **whereas** such acts of international pollution should have been totally **condemned.**

Convention on Ocean Dumping

The IGWG, have made recommendations in their special fields for action at national and international levels. Of these reports, the document on marine pollution was drafted at a convention held in Ottawa, and refurbished in further meetings to prepare a report of the Convention on Ocean Dumping. **It is amazing that the Convention which has expressed its concern about marine ecology from indiscriminate dumping of wastes from merchant ships should be silent about the chemical warfare agents and military wastes dumped in the ocean after the last war (1939-45). The influence of Big Powers on the Convention and the U.N. Conference as a whole can be seen from a careful study of the draft of the Convention.**

For example, the third draft of the Convention, exempts such disposal action in the following clause :

> "The provisions of this convention shall not apply to warships or military aircraft or other ships or aircraft owned or operated by a party and used, for the time being, only on government non-commercial service. Each party undertakes to adopt appropriate measures assuring that requirements equivalent to those of this convention are, so far as possible, applied to such vessels and aircraft of its registry, or flying its flag."

The exemption could perhaps be explained away as acceptance of the inevitability of such disposals, and the possibilities of chance accidents to aircraft carrying bombs, as also due to the secrecy associated with such operations. This country should scrutinize each clause before it decides to join the convention when formed. The wise course is to stay away for about a decade and review the position on the basis of performance.

INTERNATIONAL POLLUTANTS

The need to hold the International Conference on Human Environment arose because of the worsening environmental conditions in the West. But, instead of turning the **searchlight** on disposal practices in Developed countries, the proceedings of PREPCOM focus on the likely degradation of environment in Developing countries. International pollutants such as radioactive fallout and pesticides given as examples, and oil spills, are of Western origin and injection and therefore the responsibility for monitoring and assessment should be with these nations.

Monitoring is an essential requirement for assessing pollution. It is only through international collaboration that world statistics can be compiled to judge the status of international pollution. For success and reliability, the IGWG has rightly pointed out that it is necessary to adopt uniform techniques, standards, and methods of measurement. The IGWG drafts naturally deal with generalities but the details of working and approach are pretty well known. Although it is not defined how far national vigilance extends and from where international surveillance starts, it may be presumed that the national boundaries of inspection stretch up to its territorial waters where surveillance responsibility is totally national.

It is amazing that the Convention which has expressed its concern with indiscriminate dumping of wastes from merchant vessels, should be silent about the chemical warfare agents and military wastes dumped in the ocean.

by
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Health Physics Division,
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It s meaningless to internationalise and expand the area of monitoring of what is purely a national responsibility in its domain.

NEW EMPHASIS ON DEVELOPMENT

An important contribution of the PREPCOM is a document, called 'Development and Environment' known as the Founex Report which deals with possible consequences of industrialisation in Developing countries from experiences of distortions in the West, and the impact of such degradation on international trade and aid. The Report states :

> "It is usually recognised that high rates of economic growth, necessary and essential as they are, do not by themselves guarantee easing of urgent social and human problems. Indeed, in many countries high growth rates have been accompanied by increasing unemployment, rising disparities in income between groups and regions, and deterioration of social and cultural conditions.'

The Report propounds a new emphasis on development, somewhat like recommending dieting to a poor man after observing a rich man suffering from indigestion. The Founex report has, no doubt, made many valuable contributions regarding national policies on various aspects of the environment and development as a whole. The failings of the Report arise because of its viewing of the Developing countries through Western eyes. For a correct appreciation of the problems, it is necessary to (i) establish national priorities (ii) study methods of deve-

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lopment, and (iii) survey the status of environmental pollution in the country.

SEMINAR AT BARC — NATIONAL STUDIES *

The first national effort preparatory to the UN Conference was the Seminar on Environmental Pollution convened at the Bhabha Atomic Research Centre, Trombay in August 1970 which Shri H. N. Sethna (Chairman, AEC) called a **'national forum to take stock of the environmental situation and institute preventive action and controls'.** Practising scientists and Public Health engineers working in the field of pollution control and abatement discussed for two days the problems of environment in different parts of the country. The late Dr. Sarabhai termed it as "a meet to lay the foundation for an ongoing study of the subject" and gave examples of environmental studies carried out at Trombay and Tarapur. Welcoming the Government's move to legislate on pollution control in air and water, he added that **"the measures for regulatory enforcement are basically dependent on the understanding of phenomena and it is here that this group of professionals, scientists and engineers can contribute most effectively by rallying their totality of understanding."** Similar conferences were held in many parts of the country, bringing out regional and special industrial aspects of pollution.

FOUNEX REPORT — DISTORTIONS OF WEST APPLIED

The problems of human environment in India, and the Western countries are so dissimilar that it is difficult to agree with the conclusion of the PREPCOM experts who have seen the developing programmes through the distortions of the West. The problems of housing, slums, poverty, unemployment and degraded environment in India are partly due to the neglect of the human environment during the last war (1939-45) when massive urbanisation started in the wake of war industries. It was essentially due to neglect of planned development projects commensurate with the requirements of the population during the long period of colonial rule, when the Western nations were "strip mining and smoke stacking" to prosperity.

In the developing countries, over the years a reaction to aid has been building up because of the political strings attached. These countries entertain technical collaboration but try to be self-reliant knowing fully well that no financial aid can ever match the massive resources needed to upgrade the standards of living of their people and enhance the quality of the environment. This naturally results in a slow pace of development, allowing time for due deliberations of planned development, correct choice of site and good utilisation of men and material. **The evils of non-planned industrialisation, and consequent degradation of the environment can therefore be avoided.**

This country should weigh each clause before it decides to join the convention when formed. The wise course is to stay away for about a decade and review the position on the basis of performance.

While domestic waste is the more dominant, the present extent of industrial and agricultural pollution is small in comparison. Acute pollution, slums, overcrowding, shortage of all kinds are extensively present in large cities because they are also big industrial areas with ample employment opportunities. To prevent further impairment, separate estates are being earmarked for location of industries. Human settlements are thus segregated from toxic fumes by distance. Where habitations have grown near centres of intense industrialisation, corrective measures, including legal enforcement of control action may be called for but the conditions as such in the country have not reached a point of no return. Now that regulatory legislation is being enacted, it will be further possible to manage problem areas of pollution adequately by controlled development and legislation. **It is not correct to infer that the distortions of the West from rapid industrialisation will be repeated in the Developing countries because there is neither the competitive economy and social order in the latter nor do their resources allow a comparable fast pace of development.**

Environmental Goals (Founex)

The Founex Report recommends that Developing countries must redifine their environmental goals to balance gross prosperity against actual benefits, and set a goal of minimum environmental standards according to their resources. 'It is important that the social costs should be ascertained before undertaking development projects so that the society can carefully choose whether these costs are worthwhile...'

This is dangerous advice to countries where unemployment is high and the standards of living are low.

Negative Side Effects

Cautioning against indiscriminate development, the Report has described environmental side effects accompanying development which react adversely on the environment. Of these, resources deterioration, biological pollution and social disruption, are considered particularly relevant to Developing countries.

Such negative effects flowing from large industrial units (like an Atomic Power Station), are avoided in this country by elaborate study of the design, and the proposed location. The site is chosen on the basis of easy availability of raw supplies, trade routes, water, power and disposal facilities; the settlement are planned with due considerations of direction of wind and effluent movement with respect to site. In fact recent experience of safe siting of large industries in rural areas has served to advance local ideas and conditions of sanitation, housing, roads, lighting, hospitals, market places and educational facilities, This kind of progress would not have taken place otherwise for a

* See Nuclear India, June 1970, Sept., 1970 and Jan.-Feb. 1971.

long time. **Planned industrialisation in rural areas is possibly the only answer to keep away slums in cities and bring prosperity and sanitation to the countryside.**

Neo-protectionism in Trade

The Founex Report expresses serious concern that 'neo-protectionism' in trade may hold out a major threat to exports from Developing countries. The Developed countries could keep down competition by successfully arguing that imports from Developing countries based on less rigorous environmental standards should either be taxed or banned. A question which may also be asked in these countries is : Why be liberal in admitting the products of "sweated labour" from a "sweated environment ?" The Developed countries may even invoke high standards unilaterally to keep away imports. Further, this can lead to an argument against transfer of technology to Developing countries.

These are fantastic fears. Imports of raw hide, oil, coal, minerals, including radioactive ores into Developed countries are not objected to although they are highly pollutive, nor discussed, obviously because such imports are governed by urgency of need. Instead, examples of fruits and vegetables have been quoted on the grounds of DDT content. One of the objectives of the Conference is to remove these misapprehensions and to establish a dialogue between the Developed and the Developing countries.

Trade is bilateral, the importers and suppliers negotiating according to agreed specifications and rules of contract. Any talk of unilaterally vetoing trade agreements on account of sudden revision of standards cannot escape operation of the penalty clause. The impression one gains from the Founex Report

(Continued on next column)

Under well planned development, and with responsible management of the industry, pollution need not be an antithesis to technological progress or an obstacle to development itself.

Technology Must Release Man from Drudgery

(Continued from page 7)

mental planning without the involvement of the entire population at all levels — of architects and contractors, of technicians and rural workers, of horticulturists and foresters, in fact of all citizens? To design and construct private and public buildings and other structures which blend with their surroundings and are appropriate to the climate and customs and yet are durable and inexpensive, is the task of our architects and engineers. Because of the vast numbers of people whom we have to serve and the very limited resources we have at our disposal, we must make the maximum use of locally available materials for building and other purposes.

Many environmental problems, particularly those involving the contamination of rivers, oceans and atmosphere, are regional if not global in scope and impact. To understand and tackle such problems effectively we shall have to work closely with our neighbours in the Asian region and farther afield. Twenty per cent of the world's population consumes eighty per cent of the natural resources of the globe and produces about ninety per cent of the world's wastes and pollution. How can this situation be regarded as compatible with the concept of an equitable world order which is enshrined in the UN Charter? Problems of development and environmental survey call for major changes in the economic relations between affluent and the developing countries. Unfortunately, in the name of environmental improvement some scientists in the advanced countries recommend economic policies which will further depress the developing countries. One of our immediate goals is to be self-reliant in the economic sphere. Is it not as important to be independent in our thinking? We must be able not only to choose our direction but to know where to stop and when to turn. We should be mature enough to resist the temptation of non-essentials which glitter for a while. It is only when man is able to make the right choice at every stage and to distinguish between the essential and the expendable that he can give attention to the more worthwhile aim of improving himself and finding fulfilment.

I should have thought that progress would mean an enriching of the spirit and clarity of mind so that man would become more sensitive and aware and would think more precisely and comprehensively. He should have the capacity to live at peace with himself, with his fellowmen and with nature. Technology must bring us comfort and freedom from drudgery. But we find that in countries which have reached the stage of affluence, an ever-increasing number of thinking people are acutely unhappy and attempting various methods of escape. Most of the others believing what is fed to them by the many glossy magazines and oblivious to the emptiness of their own lives become engrossed in the race for more possessions as if that were a substitute for a full life. Man's wild spirit has been creator and destroyer. Now, with the possibility of destruction so starkly real we must concentrate on the arts of preservation. ●

is that the Developing countries are a helpless lot left totally at the mercy of the richer nations for their progress and trade.

The environmental movement which primarily started because of the alarming degradation of the environment in Developed nations has turned around at Stockholm and is instead likely to forestall progress itself in Developing nations by generating false fears of degradation of environment. Under well-planned development, and with responsible management of the industry, pollution need not be an antithesis to technological progress or an obstacle to development itself. Public education in hazards of pollution and preventive steps, will stem further degradation of the environment.

DIFFERENT ANIMALS: NEW KNOWLEDGE?

by John Newell

The comparatively few species of animals which are used for scientific research are bred mainly because their bodies work in similar ways to that of the human animal. But medical scientists are now hopeful that equally important things can be learnt from animals because of the ways they differ from human beings.

THIS is why Dr Idwal Wyn Rowlands, of the Wellcome Institute of Comparative Physiology in London, has been experimenting with the breeding in captivity of stoats, porcupines, some rare species of bats and the small mammals called elephant shrews. Each of these creatures has strange features embodied in its reproductive cycle from which we may be able to discover better ways of modifying human reproduction for our own benefit.

For example, porcupines and other allied species such as the coypu and the giant guinea pigs of South America have remarkably long gestation periods, up to 230 days for the porcupine. Perhaps we can learn from this how to slow down or speed up foetal development and what controls the rate of development of the human foetus.

The elephant shrews — little, long-snouted, insect-eating creatures from South and East Africa, have the strange habit of producing about 50 fertile eggs at a time, nearly all of which are fertilised during mating and begin to develop as embryos. But only two at the most come to full term, for the other embryos stop developing at an early stage and are re-absorbed into the body. Study of this strange and apparently wasteful phenomenon may tell scientists why in human mothers some embryos stop developing at an early age and are re-absorbed by the wall of the uterus.

The stoat's peculiarity is quite different. It has evolved a remarkable mechanism to avoid excessive inbreeding as a result of matings between siblings. Female stoats mate when they are only a few weeks old, before they have even been weaned. Of course, they are much too immature to bear young, so though the eggs are fertilised, the embryos stop developing when they are not much bigger than pinheads. They stay in a state of suspended animation in the uterus for more than half a year until the stoat has grown big enough to produce and feed a family. Male stoats are much less precocious. They do not become sexually mature until they are about a year old, so this system prevents incestuous inter-breeding between siblings, because the young females have to look to mature strangers for their first matings. If we can discover how the stoat stops her embryo developing, we may learn a lot about how human embryonic development is controlled. We may even develop new contraceptives.

Strangest of all and perhaps most potentially valuable to human medicine is a reproductive peculiarity of certain species of bats. These mate at the end of the summer just before starting their winter's hibernation. Conception however does not occur. Instead, the sperm from the male bat is kept alive in the uterus for more than half a year during hibernation until the spring, when ova are produced and fertilisation and normal development of the young occur quite normally. Electron microscope pictures have revealed that the sperms are kept alive by becoming arranged in lines along the wall of the uterus. Tiny tubes called villi then grow out from the wall of the uterus and supply the sperms with nutrients. It is far-fetched, but not impossible to hope that this process may eventually give some clues to finding better ways to support the existence of human sperm so as to help in the treatment of some cases of infertility. (SPECTRUM 1972 No. 92).

Aplastic Anemia in Bomb Survivors

A "small' increased incidence of aplastic anemia, a bone morrow disease, has been found in atomic bomb survivors by the Atomic Bomb Casualty Commission. An ABCC study of survivors in Hiroshima and Nagasaki since 1950 shows the relative risk of the disease among persons who received 1 rad or more of radiation is 1.8, compared to the risk for those receiving less than 1 rad. (About 54 percent received more than 1 rad, most between 1 and 99 rads, as estimated by the ABCC).

In all, 40 cases were found among the some 80,000 survivors. The researchers call the increased risk "not statistically significant." There was no increased risk with increased dose.

Various radiation studies have shown that the greatest risk of the disease is within five years of irradiation, with a decline thereafter. The ABCC team postulates, that in persons surviving more than five years, as their sample did, "the risk of developing an aplastic anemia-like condition due to bone morrow disturbances may not differ from those exposed to negligible doses or the non-exposed. (*"Nuclear News", May* 1972)

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 1, and printed by him at Conway Printers Pvt. Ltd., 167c, Dr. A. B. Road, Worli, Bombay 18.

Registered No. R. N. 9002/62

